

1. A data storage and/or retrieval system implemented on one or more digital data processing systems, comprising:

storage media comprising a plurality of data tunnels for each entity type and a fixed plurality of data tunnels for each attribute, one or more of which data tunnels comprise a plurality of data cells,

where each of the data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where for one or more of the data tunnels, the data cells in each of which have data for which a respective operator evaluates to a boolean result indicating either the likely possibility or the impossibility of a respective instance of an attribute being characterised by said operator for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more data tunnels based on one or more of said operators and a given set of one or more operands.
2. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81 comprising

storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result

which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

3. A data storage and/or retrieval system of claim 2, comprising

storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands and where the majority of connective data cells yield a like result for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

4. A data storage and/or retrieval system of claim 3, wherein

the connective data cell contains a digest of the respective instance of the attribute,

the respective connective data tunnel is chosen from a defined hash encoding of the respective instance of the attribute and by applying a modulo of the number of the plurality of connective data tunnels to said hash encoding.

5. A data storage and/or retrieval system of claim 4, wherein the digest of the respective instance of the attribute is the value of the respective instance itself when the size of the respective instance is sufficiently small, whereby the equivalence operator can be certain of equivalence.
6. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, comprising
- storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,
- where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,
- wherein each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,
- where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,
- a storage engine that is in communications coupling with the storage media and that accesses one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.
7. A data storage and/or retrieval system of claim 6, wherein
- each instance of a respective attribute is expressed in unitary scale and as a significand with respect to a fixed radix point,
- each combinative data tunnels is respective to part of the said significand,
- all combinative data tunnels are mutually exclusive in respect of the said significand

all combinative data tunnels enclose the whole of the said significand

8. A data storage and/or retrieval system of claim 7, the further improvement for the evaluation of a bounding operator during the read access of said combinative tunnels of said attribute of said storage system, comprising the steps of
- converting each respective boundary operand in the said bounding operator to a significand of unitary scale with a fixed radix point;
- comparing the significand bits of respective boundary operands in descending significance order to find the first significand bit that differs between said operands and taking all prior common bits as a determinant data value;
- finding the combinative data tunnel of lowest significance that comprises a strict subset of the significance of said determinant value and taking said combinative data tunnel as the determinant data tunnel;
- accessing the said determinant data tunnel first before other combinative data tunnels respective of said attribute;
- inspecting all combinative data cells of said determinant data tunnel and deeming the relevance of each respective entity instance as impossible for said bounding operator where said combinative data cell is not equal to the said determinant data value; whereby only combinative data cells, respective of entity instances not deemed of impossible relevance, in combinative data tunnels other than said determinant data tunnel need be inspected for the purposes of determining relevance of respective entity instances to the respective bounding operator and its respective operands.
9. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, comprising
- storage media comprising a plurality of characteristic data tunnels for each entity type and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute possessing a property for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

10. A data storage and/or retrieval system of claim 9, wherein

each characteristic data tunnel is respective of one or more properties.

a characteristic data cell contains a boolean indication of possession of a respective property by the respective instance of the attribute,

11. A data storage and/or retrieval system of claim 10, wherein a characteristic tunnel is chosen to be respective of a property by hash encoding the property identity and applying a modulo of the number of plurality of characteristic data tunnels to said hash encoding.

12. A data storage and/or retrieval system of claim 10, wherein a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned and T is the number of characteristic tunnels.

13. A data storage and/or retrieval system of claim 10, wherein a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing

ordinal to each unique property identity for the respective attribute and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned for the respective attribute and T is the number of characteristic tunnels.

14. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, comprising

storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,

where each collective data tunnel contains data associated with a respective instance of an entity type.

where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

15. A data storage storage and/or retrieval of claim 14, wherein a collective data cell characterised as one of identity comprises of a sequence of bits that denote the identity such that certainty of equivalence of identity for the respective instance of the respective attribute can be determined by comparison of said bits in like sequence order.

16. A data storage and/or retrieval system of claim 14, wherein a collective data cell characterised as one of measurement comprises of a sign bit, a plurality of significand bits and a plurality of exponent bits such that certainty of a respective instance of the respective attribute being bounded by a range can be determined by comparison of the respective sign, significand and exponent bits.

17. A data storage and/or retrieval system of claim 14, wherein a collective data cell characterised as one of enumeration comprises of a plurality of properties wherein each property is comprised of a sequence of bits such that certainty of possession of a property

by the respective instance of the respective attribute can be determined by a comparison of said bits in like sequence order for one or more respective properties.

18. A data storage and/or retrieval system of claim 14, wherein each data tunnel is individually encrypted during write access to storage and individually decrypted during read access from storage.
19. A data storage and/or retrieval system of claim 14, wherein each data cell is individually encrypted during write access to storage and individually decrypted during read access from storage.
20. A data storage and/or retrieval system of any of claims 1, 14, 45, 75, 76, 77, 79, and 81, wherein a specific set of one or more tunnels are accessed for each of the said operators and their respective operands, that comprise a query.
21. A data storage and/or retrieval system of claim 20, wherein one or more data tunnels are accessed independently and simultaneously for the evaluation of each said operators and their respective operands
22. A data storage and/or retrieval system of claim 20, wherein each operator evaluation includes a boolean indication of certainty or uncertainty for each respective instance deemed likely possible.
23. A data storage and/or retrieval system of claim 22, wherein operator evaluations are combined conjunctively for a common respective entity type such that some uncertain respective entity instances may be discarded from operator evaluations.
24. A data storage and/or retrieval system of claim 22, wherein subsequent materialisation of an operator evaluation can resolve any uncertainty by inspecting the respective collective data cell for the respective instance of an attribute deemed uncertain.
25. A data storage and/or retrieval system of claim 20, wherein data tunnels are read accessed in bulk from storage media for the evaluation of each said operators and their respective operands

26. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective data cells in corresponding data tunnels.
27. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective connective data cells in corresponding connective data tunnels.
28. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein a plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.
29. A data storage and/or retrieval system of claim 28, wherein a plurality of connective data tunnels and respective operators relate to instances of entities of arbitrary structure.
30. A data storage and/or retrieval system of claim 28, wherein a plurality of combinative data tunnels and respective operators relate to instances of entities of arbitrary structure.
31. A data storage and/or retrieval system of claim 28, wherein a plurality of characteristic data tunnels and respective operators relate to instances of entities of arbitrary structure.
32. A data storage and/or retrieval system of claim 28, wherein a plurality of data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
33. A data storage and/or retrieval system of claim 32, wherein a plurality of connective data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
34. A data storage and/or retrieval system of claim 32, wherein a plurality of combinative data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.

35. A data storage and/or retrieval system of claim 32, wherein a plurality of characteristic data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
36. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
37. A data storage and/or retrieval system of claim 36, wherein connective data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
38. A data storage and/or retrieval system of claim 36, wherein combinative data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
39. A data storage and/or retrieval system of claim 36, wherein characteristic data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
40. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, the further improvement for discerning from a database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of
- discerning an applicability of an equivalence operator from relationship constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;
- discerning the applicability of a bounding operator from the numerical or time domain or arithmetic domain constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

discerning the applicability of a possessive operator from the character domain or enumeration domain constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute;

discerning the inapplicability of said operators from the object or binary domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.

41. A data storage and/or retrieval system of claim 40, whereby the further improvement for discerning from a relational database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of

discerning an applicability of an equivalence operator from primary key and foreign key constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

discerning the applicability of a bounding operator from the numerical or time domain or arithmetic check constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

discerning the applicability of a possessive operator from the character domain or enumeration check constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute;

discerning the inapplicability of said operators from the large object domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.

42. A data storage and/or retrieval system of any of claims 1, 14, 45, 75, 76, 77, 79, and 81, the further improvement for accessing data tunnels for the purpose of materialising a query result, comprising the steps of

re-factoring the query expression to produce a disjunctive normal form expression of operators and their respective operands;

removing each operator and respective operands from each conjunctive term of said disjunctive normal form expression where the outcome of said operator is implied by one or more other operators in the same said conjunctive term;

removing each conjunctive term from said disjunctive normal form expression where said conjunctive term contains an operator and respective operands that is deemed to be always false;

evaluating each operator of said disjunctive normal form expression where said operator is respective of a single entity type to produce a separate relevant set of entity instances for each said operator independently and simultaneously for each said operator, for storage in computer memory;

reducing said relevant sets of entity instances where said sets are respective of a common entity type such that members of said sets not respective to every said set for said entity are discarded to produce a common set of entity instances for said entity type independently and simultaneously for each respective entity type in each conjunctive term of said disjunctive normal form, for storage in computer memory;

correlating said common sets of entity instances for said entity types paired by binding operators in a sequence to produce a correlated set of entity instances for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

accessing data tunnels respective to each said correlated set of entity instances to produce a set of query result instances independently and separately for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

marking query result instances as void where query result instances conflict with the respective conjunctive term independently and simultaneously for each said conjunctive term, for storage in computer memory;

merging said sets of query result instances for each said conjunctive term such that respective query result instances from each said set are combined into a single set of query result instances, for storage in computer memory;

43. A data storage and/or retrieval system of claim 42, the further improvement for correlating said common sets of entity instances within said conjunctive term for the purpose of producing a correlated set of entity instances, comprising the steps of
- correlating pairs of common sets of entity instances across a mutually respective bind operator in a defined visit sequence of bind operators, for storage in memory;
- updating the cardinality of entity instances in respective correlated sets of entity instances in reverse order of said visit sequence, for storage in memory.
44. A data storage and/or retrieval system of claim 43 the further improvement for deciding said visit sequence of said bind operators with said conjunctive term, comprising the steps of
- selecting a common set of entity instances with the least number of respective entity instances within said conjunctive term as the origin set of entity instances;
- selecting one of the said bind operators respective to the said origin set of entity instances as the first bind operator in the said visit sequence;
- selecting a subsequent bind operator from those bind operators respective to the same common set of entity instances as the bind operator most recently visited and which have not appeared in the said visit sequence or which have already appeared in said visit sequence but have been affected by a bind operator subsequently visited;
- repeating the prior step until no more bind operators are available to be selected; such that correlated sets of entity instances are produced in the said visit sequence for storage in computer memory.
45. A data storage and/or retrieval system implemented on one or more digital data processing systems, comprising

storage media comprising a plurality of data segments for each instance of an entity type manipulated by a database operation in a respective database transaction

where all data segments are maintained within a contiguous data heap of arbitrary size;

where all new data segments are appended to the data heap and assigned to respective transactions and respective entity instances in arbitrary order;

a storage engine that is in communications coupling with the storage media and writes said data heap to storage media in a minimal number of storage write operations when any one of said transactions commits its state.

46. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein storage write operations are performed such that all said data segments within said data heap are written to storage in a minimum of storage write requests.
47. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein storage write operations for said data heap only occur at predefined regular intervals, such that transactions committing their state cannot complete said commit until the next storage write operation for said data heap has successfully completed.
48. A data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein
- an instance of a entity type is logically deleted by appending an inversion of the respective instance,
- the said inversion appears identical to the respective instance in all respective connective, combinative and characteristic data tunnels;
- a single inversion data tunnel for each entity type contains a plurality of data cells wherein a data cell denotes an inversion of a respective instance of said entity type.
49. A data storage and/or retrieval system of claim 48, wherein

append access to data tunnels and data heaps occurs in chronological order,

read access to data tunnels and data heaps occurs in reverse chronological order

read access resolves entity instance inversion by accumulating inversions and discounting corresponding entity instances as they are encountered.

50. The data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of their respective entity instances.
51. The data storage and/or retrieval system of claim 50, wherein a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of the respective entity instances such that cells across all tunnels respect common frame boundaries.
52. The data storage and/or retrieval system of claim 51, wherein said common characteristic is time period.
53. The data storage and/or retrieval system of claim 52, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media with respect to the age of the data retained.
54. The data storage and/or retrieval system of claim 52, comprising a database engine that is coupled to the storage engine and that eliminates frames from read access during a query with respect to a time threshold expressed within said query.
55. The data storage and/or retrieval system of claim 51, wherein said common characteristic is volume of respective entity instances
56. The data storage and/or retrieval system of claim 55, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media with respect to the volume of the data retained.

57. The data storage and/or retrieval system of claim 51, wherein a plurality of data cells respective of a plurality of data tunnels respective of a plurality of frames are accumulated within a single logical storage system file of a plurality of logical storage system files.
58. The data storage and/or retrieval system of claim 51, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media.
59. The data storage and/or retrieval system of claim 50, wherein a common characterisation of respective cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective operator and its operands.
60. The data storage and/or retrieval system of claim 59, wherein a plurality of bit sequences common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective equivalence operator and its operands.
61. The data storage and/or retrieval system of claim 59, wherein bounds common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective bounding operator and its operands.
62. The data storage and/or retrieval system of claim 59, wherein properties common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective possessive operator and its operands.
63. The data storage and/or retrieval system of any of claims 1, 45, 75, 76, 77, 79, and 81, wherein a plurality of said data segments are grouped in frames based on common characteristics of their respective entity instances.

64. The data storage and/or retrieval system of claim 63, wherein said common characteristic is time period.
65. The data storage and/or retrieval system of claim 63, wherein said common characteristic is volume of respective entity instances.
66. The data storage and/or retrieval system of claim 63, comprising a storage engine that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame.
67. The data storage and/or retrieval system of claim 66, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame, as and when each frame becomes complete.
68. The data storage and/or retrieval system of claim 66, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a plurality of complete frames, as and when said plurality of frames become complete.
69. A data storage and/or retrieval system of claim 66, the further improvement for resolution of duplicate entity instances during query access of said storage system, comprising the steps of
- assigning said frames of the data storage system of claim 63 in identical manner to that used for the data storage system of claim 50;
- accessing said frames of the data storage system of claim 63 prior to accessing said frames of the data storage system of claim 50 during said query access;
- discounting any said frames in the data storage system of claim 50 that correspond to said frames accessed in the data storage system of claim 63 during said query access; such that each entity instance can be persisted in the data storage system of claim 63 and in the data storage system of claim 50 at the same time to ensure persistence of said entity instances without affecting the result of said query access.

70. The data storage and/or retrieval system of any of claims 1, 14, 45, 75, 76, 77, 79, and 81, wherein a complete definition of respective entity types and respective attributes is stored within distinct storage system file identified by a unique version identity whenever said definition is changed.
71. The data storage and/or retrieval system of claim 70, wherein each distinct entity type definition is assigned a unique ordinal identity from a single monotonically increasing ordinal number sequence.
72. The data storage and/or retrieval system of claim 70, wherein each distinct attribute definition is assigned a unique ordinal identity from a monotonically increasing ordinal number sequence for the respective entity type.
73. The data storage and/or retrieval system of claim 70, wherein each complete definition is assigned a unique version identity from a single monotonically increasing version number sequence.
74. The data storage and/or retrieval system of claim 70 and/or claim 50, wherein each complete definition is assigned the identity of the respective frame in which said definition is created.
75. A data storage and/or retrieval system, comprising
- storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,
- where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,
- wherein each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,
- where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result

which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

76. A method of data storage and/or retrieval system implemented on one or more digital data processing systems, comprising:

providing storage media comprising a plurality of data tunnels for each entity type and a fixed plurality of data tunnels for each attribute, one or more of which data tunnels comprise a plurality of data cells,

where each of the data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where for one or more of the data tunnels, the data cells in each of which have data for which a respective operator evaluates to a boolean result indicating either the likely possibility or the impossibility of a respective instance of an attribute being characterised by said operator for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media, one or more data tunnels based on one or more of said operators and a given set of one or more operands.

77. A data storage and/or retrieval system, comprising

storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands and where the majority of connective data cells yield a like result for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

78. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

providing storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media, one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

79. A data storage and/or retrieval system, comprising

storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,

where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

80. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

providing storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,

where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result

which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media, one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

81. A data storage and/or retrieval system, comprising

providing storage media comprising a plurality of characteristic data tunnels for each entity type and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute possessing a property for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media, one or more characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

82. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

providing storage media comprising a plurality of characteristic data tunnels for each entity type and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

wherein each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute possessing a property for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media, one or more characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

83. A method data storage and/or retrieval, comprising

providing storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,

where each collective data tunnel contains data associated with a respective instance of an entity type.

where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

84. A method data storage and/or retrieval, comprising

providing storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,

where each collective data tunnel contains data associated with a respective instance of an entity type.

where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

85. The method of any of claims 76, 78, 80, 82 - 84, wherein

the connective data cell contains a digest of the respective instance of the attribute,

the respective connective data tunnel is chosen from a defined hash encoding of the respective instance of the attribute and by applying a modulo of the number of the plurality of connective data tunnels to said hash encoding.

86. The method of claim 85, wherein the digest of the respective instance of the attribute is the value of the respective instance itself when the size of the respective instance is sufficiently small, whereby the equivalence operator can be certain of equivalence.

87. The method of any of claims 76, 78, 80, 82 - 84, wherein

each instance of a respective attribute is expressed in unitary scale and as a significand with respect to a fixed radix point,

each combinative data tunnels is respective to part of the said significand,

all combinative data tunnels are mutually exclusive in respect of the said significand

all combinative data tunnels enclose the whole of the said significand

88. The method of claim 87, the further improvement for the evaluation of a bounding operator during the read access of said combinative tunnels of said attribute of said storage system, comprising the steps of

converting each respective boundary operand in the said bounding operator to a significand of unitary scale with a fixed radix point;

comparing the significand bits of respective boundary operands in descending significance order to find the first significand bit that differs between said operands and taking all prior common bits as a determinant data value;

finding the combinative data tunnel of lowest significance that comprises a strict subset of the significance of said determinant value and taking said combinative data tunnel as the determinant data tunnel;

accessing the said determinant data tunnel first before other combinative data tunnels respective of said attribute;

inspecting all combinative data cells of said determinant data tunnel and deeming the relevance of each respective entity instance as impossible for said bounding operator where said combinative data cell is not equal to the said determinant data value; whereby only combinative data cells, respective of entity instances not deemed of impossible relevance, in combinative data tunnels other than said determinant data tunnel need be inspected for the purposes of determining relevance of respective entity instances to the respective bounding operator and its respective operands.

89. The method of any of claims 76, 78, 80, 82 - 84, wherein

each characteristic data tunnel is respective of one or more properties.

a characteristic data cell contains a boolean indication of possession of a respective property by the respective instance of the attribute,

90. The method of claim 89, wherein a characteristic tunnel is chosen to be respective of a property by hash encoding the property identity and applying a modulo of the number of plurality of characteristic data tunnels to said hash encoding.

91. The method of claim 89, wherein a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property

identity and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 83T$ where P is the ordinal of the property; M is the maximum ordinal assigned and T is the number of characteristic tunnels.

92. The method of claim 89, wherein a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity for the respective attribute and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 83T$ where P is the ordinal of the property; M is the maximum ordinal assigned for the respective attribute and T is the number of characteristic tunnels.
93. A data storage storage and/or retrieval of any of claims 76, 78, 80, 82 - 84, wherein a collective data cell characterised as one of identity comprises of a sequence of bits that denote the identity such that certainty of equivalence of identity for the respective instance of the respective attribute can be determined by comparison of said bits in like sequence order.
94. The method of claim 92, wherein a collective data cell characterised as one of measurement comprises of a sign bit, a plurality of significand bits and a plurality of exponent bits such that certainty of a respective instance of the respective attribute being bounded by a range can be determined by comparison of the respective sign, significand and exponent bits.
95. The method of claim 92, wherein a collective data cell characterised as one of enumeration comprises of a plurality of properties wherein each property is comprised of a sequence of bits such that certainty of possession of a property by the respective instance of the respective attribute can be determined by a comparison of said bits in like sequence order for one or more respective properties.
96. The method of claim 92, wherein each data tunnel is individually encrypted during write access to storage and individually decrypted during read access from storage.

97. The method of claim 92, wherein each data cell is individually encrypted during write access to storage and individually decrypted during read access from storage.
98. The method of any of claims 76, 78, 80, 82 - 84 and/or claim 92, wherein a specific set of one or more tunnels are accessed for each of the said operators and their respective operands, that comprise a query.
99. The method of claim 98, wherein one or more data tunnels are accessed independently and simultaneously for the evaluation of each said operators and their respective operands
100. The method of claim 98, wherein each operator evaluation includes a boolean indication of certainty or uncertainty for each respective instance deemed likely possible.
101. The method of claim 100, wherein operator evaluations are combined conjunctively for a common respective entity type such that some uncertain respective entity instances may be discarded from operator evaluations.
102. The method of claim 100, wherein subsequent materialisation of an operator evaluation can resolve any uncertainty by inspecting the respective collective data cell for the respective instance of an attribute deemed uncertain.
103. The method of claim 98, wherein data tunnels are read accessed in bulk from storage media for the evaluation of each said operators and their respective operands
104. The method of any of claims 76, 78, 80, 82 - 84, wherein distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective data cells in corresponding data tunnels.
105. The method of any of claims 76, 78, 80, 82 - 84, wherein distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective connective data cells in corresponding connective data tunnels.
106. The method of any of claims 76, 78, 80, 82 - 84, wherein a plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.

107. The method of claim 106, wherein a plurality of connective data tunnels and respective operators relate to instances of entities of arbitrary structure.
108. The method of claim 106, wherein a plurality of combinative data tunnels and respective operators relate to instances of entities of arbitrary structure.
109. The method of claim 106, wherein a plurality of characteristic data tunnels and respective operators relate to instances of entities of arbitrary structure.
110. The method of claim 106, wherein a plurality of data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
111. The method of claim 110, wherein a plurality of connective data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
112. The method of claim 110, wherein a plurality of combinative data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
113. The method of claim 110, wherein a plurality of characteristic data tunnels and respective operators relate to instances of an entity type wherein distinct instances of said entity type differ in structure.
114. The method of any of claims 76, 78, 80, 82 - 84, wherein data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
115. The method of claim 114, wherein connective data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

116. The method of claim 114, wherein combinative data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
117. The method of claim 114, wherein characteristic data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.
118. The method of any of claims 76, 78, 80, 82 - 84, the further improvement for discerning from a database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of
- discerning an applicability of an equivalence operator from relationship constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;
- discerning the applicability of a bounding operator from the numerical or time domain or arithmetic domain constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;
- discerning the applicability of a possessive operator from the character domain or enumeration domain constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute;
- discerning the inapplicability of said operators from the object or binary domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.
119. The method of claim 118, whereby the further improvement for discerning from a relational database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of

discerning an applicability of an equivalence operator from primary key and foreign key constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

discerning the applicability of a bounding operator from the numerical or time domain or arithmetic check constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

discerning the applicability of a possessive operator from the character domain or enumeration check constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute;

discerning the inapplicability of said operators from the large object domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.

120. The method of any of claims 76, 78, 80, 82 - 84 and/or claim 92, the further improvement for accessing data tunnels for the purpose of materialising a query result, comprising the steps of

re-factoring the query expression to produce a disjunctive normal form expression of operators and their respective operands;

removing each operator and respective operands from each conjunctive term of said disjunctive normal form expression where the outcome of said operator is implied by one or more other operators in the same said conjunctive term;

removing each conjunctive term from said disjunctive normal form expression where said conjunctive term contains an operator and respective operands that is deemed to be always false;

evaluating each operator of said disjunctive normal form expression where said operator is respective of a single entity type to produce a separate relevant set of entity instances

for each said operator independently and simultaneously for each said operator, for storage in computer memory;

reducing said relevant sets of entity instances where said sets are respective of a common entity type such that members of said sets not respective to every said set for said entity are discarded to produce a common set of entity instances for said entity type independently and simultaneously for each respective entity type in each conjunctive term of said disjunctive normal form, for storage in computer memory;

correlating said common sets of entity instances for said entity types paired by binding operators in a sequence to produce a correlated set of entity instances for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

accessing data tunnels respective to each said correlated set of entity instances to produce a set of query result instances independently and separately for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

marking query result instances as void where query result instances conflict with the respective conjunctive term independently and simultaneously for each said conjunctive term, for storage in computer memory;

merging said sets of query result instances for each said conjunctive term such that respective query result instances from each said set are combined into a single set of query result instances, for storage in computer memory;

121. The method of claim 120, the further improvement for correlating said common sets of entity instances within said conjunctive term for the purpose of producing a correlated set of entity instances, comprising the steps of
- correlating pairs of common sets of entity instances across a mutually respective bind operator in a defined visit sequence of bind operators, for storage in memory;

updating the cardinality of entity instances in respective correlated sets of entity instances in reverse order of said visit sequence, for storage in memory.

122. The method of claim 121 the further improvement for deciding said visit sequence of said bind operators with said conjunctive term, comprising the steps of

selecting a common set of entity instances with the least number of respective entity instances within said conjunctive term as the origin set of entity instances;

selecting one of the said bind operators respective to the said origin set of entity instances as the first bind operator in the said visit sequence;

selecting a subsequent bind operator from those bind operators respective to the same common set of entity instances as the bind operator most recently visited and which have not appeared in the said visit sequence or which have already appeared in said visit sequence but have been affected by a bind operator subsequently visited;

repeating the prior step until no more bind operators are available to be selected; such that correlated sets of entity instances are produced in the said visit sequence for storage in computer memory.

123. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

storage media comprising a plurality of data segments for each instance of an entity type manipulated by a database operation in a respective database transaction

where all data segments are maintained within a contiguous data heap of arbitrary size;

where all new data segments are appended to the data heap and assigned to respective transactions and respective entity instances in arbitrary order;

a storage engine that is in communications coupling with the storage media and writes said data heap to storage media in a minimal number of storage write operations when any one of said transactions commits its state.

124. The method of claim 123, wherein storage write operations are performed such that all said data segments within said data heap are written to storage in a minimum of storage write requests.
125. The method of claim 123, wherein storage write operations for said data heap only occur at predefined regular intervals, such that transactions committing their state cannot complete said commit until the next storage write operation for said data heap has successfully completed.
126. The method of any of claims 76, 78, 80, 82 - 84 and/or claim 123, wherein
- an instance of a entity type is logically deleted by appending an inversion of the respective instance,
- the said inversion appears identical to the respective instance in all respective connective, combinative and characteristic data tunnels;
- a single inversion data tunnel for each entity type contains a plurality of data cells wherein a data cell denotes an inversion of a respective instance of said entity type.
127. The method of claim 126, wherein
- append access to data tunnels and data heaps occurs in chronological order,
- read access to data tunnels and data heaps occurs in reverse chronological order
- read access resolves entity instance inversion by accumulating inversions and discounting corresponding entity instances as they are encountered.
128. The method of data storage and/or retrieval of any of claims 76, 78, 80, 82 - 84, wherein a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of their respective entity instances.
129. The method of data storage and/or retrieval of claim 128, wherein a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of the

respective entity instances such that cells across all tunnels respect common frame boundaries.

130. The method of data storage and/or retrieval of claim 129, wherein said common characteristic is time period.
131. The method of data storage and/or retrieval of claim 130, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media with respect to the age of the data retained.
132. The method of data storage and/or retrieval of claim 130, comprising a database engine that is coupled to the storage engine and that eliminates frames from read access during a query with respect to a time threshold expressed within said query.
133. The method of data storage and/or retrieval of claim 129, wherein said common characteristic is volume of respective entity instances
134. The method of data storage and/or retrieval of claim 133, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media with respect to the volume of the data retained.
135. The method of data storage and/or retrieval of claim 129, wherein a plurality of data cells respective of a plurality of data tunnels respective of a plurality of frames are accumulated within a single logical storage system file of a plurality of logical storage system files.
136. The method of data storage and/or retrieval of claim 129, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media.
137. The method of data storage and/or retrieval of claim 128, wherein a common characterisation of respective cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective operator and its operands.

138. The method of data storage and/or retrieval of claim 137, wherein a plurality of bit sequences common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective equivalence operator and its operands.
139. The method of data storage and/or retrieval of claim 137, wherein bounds common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective bounding operator and its operands.
140. The method of data storage and/or retrieval of claim 137, wherein properties common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective possessive operator and its operands.
141. The method of data storage and/or retrieval of claim 123, wherein a plurality of said data segments are grouped in frames based on common characteristics of their respective entity instances.
142. The method of data storage and/or retrieval of claim 141, wherein said common characteristic is time period.
143. The method of data storage and/or retrieval of claim 141, wherein said common characteristic is volume of respective entity instances.
144. The method of data storage and/or retrieval of claim 141, comprising a storage engine that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame.
145. The method of data storage and/or retrieval of claim 144, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective entities

contained in data segments that comprise a complete frame, as and when each frame becomes complete.

146. The method of data storage and/or retrieval of claim 144, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a plurality of complete frames, as and when said plurality of frames become complete.
147. The method of claim 144, the further improvement for resolution of duplicate entity instances during query access of said storage system, comprising the steps of
- assigning said frames of the data storage system of claim 141 in identical manner to that used for the data storage system of claim 128;
- accessing said frames of the data storage system of claim 141 prior to accessing said frames of the data storage system of claim 128 during said query access;
- discounting any said frames in the data storage system of claim 128 that correspond to said frames accessed in the data storage system of claim 141 during said query access; such that each entity instance can be persisted in the data storage system of claim 141 and in the data storage system of claim 128 at the same time to ensure persistence of said entity instances without affecting the result of said query access.
148. The method of data storage and/or retrieval of any of claims 76, 78, 80, 82 - 84 and/or claim 92, wherein a complete definition of respective entity types and respective attributes is stored within distinct storage system file identified by a unique version identity whenever said definition is changed.
149. The method of data storage and/or retrieval of claim 148, wherein each distinct entity type definition is assigned a unique ordinal identity from a single monotonically increasing ordinal number sequence.
150. The method of data storage and/or retrieval of claim 148, wherein each distinct attribute definition is assigned a unique ordinal identity from a monotonically increasing ordinal number sequence for the respective entity type.

151. The method of data storage and/or retrieval of claim 148, wherein each complete definition is assigned a unique version identity from a single monotonically increasing version number sequence.
152. The method of data storage and/or retrieval of claim 148 and/or claim 128, wherein each complete definition is assigned the identity of the respective frame in which said definition is created.

CLAIMS

1. A data storage and/or retrieval system implemented on one or more digital data processing systems, comprising:

storage media comprising a plurality of data tunnels for each entity type and a fixed

5 plurality of data tunnels for each attribute, one or more of which data tunnels comprise a plurality of data cells,

where each of the data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

10 where for one or more of the data tunnels, the data cells in each of which have data for which a respective operator evaluates to a boolean result indicating either the likely possibility or the impossibility of a respective instance of an attribute being characterised by said operator for a given set of one or more operands,

15 a storage engine that is in communications coupling with the storage media and that accesses one or more data tunnels based on one or more of said operators and a given set of one or more operands.

2. A data storage and/or retrieval system according to Claim 1, comprising

storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

20 where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

25 where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

3. A data storage and/or retrieval system according to Claim 2, comprising

5 storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

10 where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands and where the majority of connective data cells yield a like result for a given set of one or
15 more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

4. A data storage and/or retrieval system according to Claim 3, in which

20 the connective data cell contains a digest of the respective instance of the attribute, the respective connective data tunnel is chosen from a defined hash encoding of the respective instance of the attribute and by applying a modulo of the number of the plurality of connective data tunnels to said hash encoding.

5. A data storage and/or retrieval system according to Claim 4, in which the digest of the
25 respective instance of the attribute is the value of the respective instance itself when the size of the respective instance is sufficiently small, whereby the equivalence operator can be certain of equivalence.

6. A data storage and/or retrieval system according to Claim 1, comprising

storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,

where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

7. A data storage and/or retrieval system according to Claim 6, in which

each instance of a respective attribute is expressed in unitary scale and as a significand with respect to a fixed radix point,

each combinative data tunnels is respective to part of the said significand,

all combinative data tunnels are mutually exclusive in respect of the said significand

all combinative data tunnels enclose the whole of the said significand

8. A data storage and/or retrieval system according to Claim 7, the further improvement for the evaluation of a bounding operator during the read access of said combinative tunnels of said attribute of said storage system, comprising the steps of

converting each respective boundary operand in the said bounding operator to a significand of unitary scale with a fixed radix point;

comparing the significand bits of respective boundary operands in descending significance order to find the first significand bit that differs between said operands and taking all prior common bits as a determinant data value;

finding the combinative data tunnel of lowest significance that comprises a strict subset of the significance of said determinant value and taking said combinative data tunnel as the determinant data tunnel;

accessing the said determinant data tunnel first before other combinative data tunnels
5 respective of said attribute;

inspecting all combinative data cells of said determinant data tunnel and deeming the relevance of each respective entity instance as impossible for said bounding operator where said combinative data cell is not equal to the said determinant data value;

whereby only combinative data cells, respective of entity instances not deemed of
10 impossible relevance, in combinative data tunnels other than said determinant data tunnel need be inspected for the purposes of determining relevance of respective entity instances to the respective bounding operator and its respective operands.

9. A data storage and/or retrieval system according to Claim 1, comprising

storage media comprising a plurality of characteristic data tunnels for each entity type
15 and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective characteristic data
20 cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a
25 respective instance of an attribute possessing a property for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

10. A data storage and/or retrieval system according to Claim 9, in which

30 each characteristic data tunnel is respective of one or more properties.

a characteristic data cell contains a boolean indication of possession of a respective property by the respective instance of the attribute,

11. A data storage and/or retrieval system according to Claim 10, in which a characteristic tunnel is chosen to be respective of a property by hash encoding the property identity and
5 applying a modulo of the number of plurality of characteristic data tunnels to said hash encoding.

12. A data storage and/or retrieval system according to Claim 10, in which a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity and applying a modulo of the number of plurality
10 characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned and T is the number of characteristic tunnels.

13. A data storage and/or retrieval system according to Claim 10, in which a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing
15 ordinal to each unique property identity for the respective attribute and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned for the respective attribute and T is the number of characteristic tunnels.

20 14. A data storage and/or retrieval system according to Claim 1, comprising
storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,
where each collective data tunnel contains data associated with a respective instance of an entity type.

25 where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

15. A data storage storage and/or retrieval according to Claim 14, in which a collective
30 data cell characterised as one of identity comprises of a sequence of bits that denote the

identity such that certainty of equivalence of identity for the respective instance of the respective attribute can be determined by comparison of said bits in like sequence order.

16. A data storage and/or retrieval system according to Claim 14, in which a collective data cell characterised as one of measurement comprises of a sign bit, a plurality of

5 significand bits and a plurality of exponent bits such that certainty of a respective instance of the respective attribute being bounded by a range can be determined by comparison of the respective sign, significand and exponent bits.

17. A data storage and/or retrieval system according to Claim 14, in which a collective data cell characterised as one of enumeration comprises of a plurality of properties in which

10 each property is comprised of a sequence of bits such that certainty of possession of a property by the respective instance of the respective attribute can be determined by a comparison of said bits in like sequence order for one or more respective properties.

18. A data storage and/or retrieval system according to Claim 14, in which each data tunnel is individually encrypted during write access to storage and individually decrypted

15 during read access from storage.

19. A data storage and/or retrieval system according to Claim 14, in which each data cell is individually encrypted during write access to storage and individually decrypted during read access from storage.

20. A data storage and/or retrieval system according to Claim 1 or 14, in which a specific set of one or more tunnels are accessed for each of the said operators and their respective operands, that comprise a query.

20

21. A data storage and/or retrieval system according to Claim 20, in which one or more data tunnels are accessed independently and simultaneously for the evaluation of each said operators and their respective operands

22. A data storage and/or retrieval system according to Claim 20, in which each operator evaluation includes a boolean indication of certainty or uncertainty for each respective instance deemed likely possible.

25

23. A data storage and/or retrieval system according to Claim 22, in which operator evaluations are combined conjunctively for a common respective entity type such that some uncertain respective entity instances may be discarded from operator evaluations.

24. A data storage and/or retrieval system according to Claim 22, in which subsequent
5 materialisation of an operator evaluation can resolve any uncertainty by inspecting the respective collective data cell for the respective instance of an attribute deemed uncertain.

25. A data storage and/or retrieval system according to Claim 20, in which data tunnels are read accessed in bulk from storage media for the evaluation of each said operators and their respective operands

10 26. A data storage and/or retrieval system according to Claim 1, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective data cells in corresponding data tunnels.

27. A data storage and/or retrieval system according to Claim 1, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of
15 their respective connective data cells in corresponding connective data tunnels.

28. A data storage and/or retrieval system according to Claim 1, in which a plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.

29. A data storage and/or retrieval system according to Claim 28, in which a plurality of connective data tunnels and respective operators relate to instances of entities of arbitrary
20 structure.

30. A data storage and/or retrieval system according to Claim 28, in which a plurality of combinative data tunnels and respective operators relate to instances of entities of arbitrary structure.

31. A data storage and/or retrieval system according to Claim 28, in which a plurality of
25 characteristic data tunnels and respective operators relate to instances of entities of arbitrary structure.

32. A data storage and/or retrieval system according to Claim 28, in which a plurality of data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

33. A data storage and/or retrieval system according to Claim 32, in which a plurality of connective data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

34. A data storage and/or retrieval system according to Claim 32, in which a plurality of combinative data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

35. A data storage and/or retrieval system according to Claim 32, in which a plurality of characteristic data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

36. A data storage and/or retrieval system according to Claim 1, in which data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

37. A data storage and/or retrieval system according to Claim 36, in which connective data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

38. A data storage and/or retrieval system according to Claim 36, in which combinative data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

39. A data storage and/or retrieval system according to Claim 36, in which characteristic data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

40. A data storage and/or retrieval system according to Claim 1, the further improvement for discerning from a database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of

discerning an applicability of an equivalence operator from relationship constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

discerning the applicability of a bounding operator from the numerical or time domain or arithmetic domain constraints for said attribute such that data for instances of said

attribute are stored in combinative data cells within combinative data tunnels
respective of said attribute;

discerning the applicability of a possessive operator from the character domain or
enumeration domain constraints for said attribute such that data for instances of said
5 attribute are stored in characteristic data cells within characteristic data tunnels
respective of said attribute;

discerning the inapplicability of said operators from the object or binary domain or
external reference for said attribute such that data for instances of said attribute are not
stored in any connective, combinative or characteristic data tunnels respective of said
10 attribute.

41. A data storage and/or retrieval system according to Claim 40, whereby the further
improvement for discerning from a relational database schema the operators and respective
data tunnels that are applicable to a respective attribute, comprising the steps of

discerning an applicability of an equivalence operator from primary key and foreign
15 key constraints for said attribute such that data for instances of said attribute are stored
in connective data cells within connective data tunnels respective of said attribute;

discerning the applicability of a bounding operator from the numerical or time domain
or arithmetic check constraints for said attribute such that data for instances of said
attribute are stored in combinative data cells within combinative data tunnels
20 respective of said attribute;

discerning the applicability of a possessive operator from the character domain or
enumeration check constraints for said attribute such that data for instances of said
attribute are stored in characteristic data cells within characteristic data tunnels
respective of said attribute;

discerning the inapplicability of said operators from the large object domain or
external reference for said attribute such that data for instances of said attribute are not
stored in any connective, combinative or characteristic data tunnels respective of said
25 attribute.

42. A data storage and/or retrieval system according to Claim 1 or 14, the further
30 improvement for accessing data tunnels for the purpose of materialising a query result,
comprising the steps of

re-factoring the query expression to produce a disjunctive normal form expression of operators and their respective operands;

removing each operator and respective operands from each conjunctive term of said disjunctive normal form expression where the outcome of said operator is implied by one or more other operators in the same said conjunctive term;

removing each conjunctive term from said disjunctive normal form expression where said conjunctive term contains an operator and respective operands that is deemed to be always false;

evaluating each operator of said disjunctive normal form expression where said operator is respective of a single entity type to produce a separate relevant set of entity instances for each said operator independently and simultaneously for each said operator, for storage in computer memory;

reducing said relevant sets of entity instances where said sets are respective of a common entity type such that members of said sets not respective to every said set for said entity are discarded to produce a common set of entity instances for said entity type independently and simultaneously for each respective entity type in each conjunctive term of said disjunctive normal form, for storage in computer memory;

correlating said common sets of entity instances for said entity types paired by binding operators in a sequence to produce a correlated set of entity instances for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

accessing data tunnels respective to each said correlated set of entity instances to produce a set of query result instances independently and separately for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

marking query result instances as void where query result instances conflict with the respective conjunctive term independently and simultaneously for each said conjunctive term, for storage in computer memory;

merging said sets of query result instances for each said conjunctive term such that respective query result instances from each said set are combined into a single set of query result instances, for storage in computer memory;

43. A data storage and/or retrieval system according to Claim 42, the further improvement for correlating said common sets of entity instances within said conjunctive term for the purpose of producing a correlated set of entity instances, comprising the steps of

correlating pairs of common sets of entity instances across a mutually respective bind operator in a defined visit sequence of bind operators, for storage in memory;

updating the cardinality of entity instances in respective correlated sets of entity instances in reverse order of said visit sequence, for storage in memory.

44. A data storage and/or retrieval system according to Claim 43, the further improvement for deciding said visit sequence of said bind operators with said conjunctive term comprising the steps of

selecting a common set of entity instances with the least number of respective entity instances within said conjunctive term as the origin set of entity instances;

selecting one of the said bind operators respective to the said origin set of entity instances as the first bind operator in the said visit sequence;

selecting a subsequent bind operator from those bind operators respective to the same common set of entity instances as the bind operator most recently visited and which have not appeared in the said visit sequence or which have already appeared in said visit sequence but have been affected by a bind operator subsequently visited;

repeating the prior step until no more bind operators are available to be selected; such that correlated sets of entity instances are produced in the said visit sequence for storage in computer memory.

45. A data storage and/or retrieval system implemented on one or more digital data processing systems, comprising

storage media comprising a plurality of data segments for each instance of an entity type manipulated by a database operation in a respective database transaction

where all data segments are maintained within a contiguous data heap of arbitrary size;

where all new data segments are appended to the data heap and assigned to respective transactions and respective entity instances in arbitrary order;

a storage engine that is in communications coupling with the storage media and writes said data heap to storage media in a minimal number of storage write operations when any one of said transactions commits its state.

46. A data storage and/or retrieval system according to Claim 1 or 45, in which storage write operations are performed such that all said data segments within said data heap are written to storage in a minimum of storage write requests.

47. A data storage and/or retrieval system according to Claim 1 or 45, in which storage write operations for said data heap only occur at predefined regular intervals, such that transactions committing their state cannot complete said commit until the next storage write operation for said data heap has successfully completed.

48. A data storage and/or retrieval system according to Claim 1 or 45, in which

an instance of a entity type is logically deleted by appending an inversion of the respective instance,

the said inversion appears identical to the respective instance in all respective connective, combinative and characteristic data tunnels;

a single inversion data tunnel for each entity type contains a plurality of data cells in which a data cell denotes an inversion of a respective instance of said entity type.

49. A data storage and/or retrieval system according to Claim 48, in which

append access to data tunnels and data heaps occurs in chronological order,

read access to data tunnels and data heaps occurs in reverse chronological order

read access resolves entity instance inversion by accumulating inversions and discounting corresponding entity instances as they are encountered.

50. A data storage and/or retrieval system of according to Claim 1 or 45, in which a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of their respective entity instances.

51. A data storage and/or retrieval system according to Claim 50, in which a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of the respective entity instances such that cells across all tunnels respect common frame boundaries.

52. A data storage and/or retrieval system according to Claim 51, in which said common characteristic is time period.

53. A data storage and/or retrieval system according to Claim 52, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage
5 media with respect to the age of the data retained.

54. A data storage and/or retrieval system according to Claim 52, comprising a database engine that is coupled to the storage engine and that eliminates frames from read access during a query with respect to a time threshold expressed within said query.

55. A data storage and/or retrieval system according to Claim 51, in which said common
10 characteristic is volume of respective entity instances

56. A data storage and/or retrieval system according to Claim 55, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media with respect to the volume of the data retained.

57. A data storage and/or retrieval system according to Claim 51, in which a plurality of
15 data cells respective of a plurality of data tunnels respective of a plurality of frames are accumulated within a single logical storage system file of a plurality of logical storage system files.

58. A data storage and/or retrieval system according to Claim 51, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage
20 media.

59. A data storage and/or retrieval system according to Claim 50, in which a common characterisation of respective cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective operator and
25 its operands.

60. A data storage and/or retrieval system according to Claim 59, in which a plurality of bit sequences common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame

interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective equivalence operator and its operands.

61. A data storage and/or retrieval system according to Claim 59, in which bounds common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective bounding operator and its operands.

62. A data storage and/or retrieval system according to Claim 59, in which properties common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective possessive operator and its operands.

63. A data storage and/or retrieval system according to Claim 1 or 45, in which a plurality of said data segments are grouped in frames based on common characteristics of their respective entity instances.

64. A data storage and/or retrieval system according to Claim 63, in which said common characteristic is time period.

65. A data storage and/or retrieval system according to Claim 63, in which said common characteristic is volume of respective entity instances.

66. A data storage and/or retrieval system according to Claim 63, comprising a storage engine that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame.

67. A data storage and/or retrieval system according to Claim 66, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame, as and when each frame becomes complete.

68. A data storage and/or retrieval system according to Claim 66, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective entities

contained in data segments that comprise a plurality of complete frames, as and when said plurality of frames become complete.

69. A data storage and/or retrieval system according to Claim 66, the further improvement for resolution of duplicate entity instances during query access of said storage system,
5 comprising the steps of

assigning said frames of the data storage system according to Claim 63 in identical manner to that used for the data storage system according to Claim 50;

accessing said frames of the data storage system according to Claim 63 prior to
accessing said frames of the data storage system according to Claim 50 during said
10 query access;

discounting any said frames in the data storage system according to Claim 50 that correspond to said frames accessed in the data storage system according to Claim 63 during said query access; such that each entity instance can be persisted in the data storage system according to Claim 63 and in the data storage system according to
15 Claim 50 at the same time to ensure persistence of said entity instances without affecting the result of said query access.

70. A data storage and/or retrieval system according to any of Claims 1, 14 and 45, in which a complete definition of respective entity types and respective attributes is stored within distinct storage system file identified by a unique version identity whenever said definition is
20 changed.

71. A data storage and/or retrieval system according to Claim 70, in which each distinct entity type definition is assigned a unique ordinal identity from a single monotonically increasing ordinal number sequence.

72. A data storage and/or retrieval system according to Claim 70, in which each distinct
25 attribute definition is assigned a unique ordinal identity from a monotonically increasing ordinal number sequence for the respective entity type.

73. A data storage and/or retrieval system according to Claim 70, in which each complete definition is assigned a unique version identity from a single monotonically increasing version number sequence.

74. A data storage and/or retrieval system according to Claim 70 and/or Claim 50, in which each complete definition is assigned the identity of the respective frame in which said definition is created.

75. A data storage and/or retrieval system, comprising

5 storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells, where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

10 in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel, where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective

15 instance of an attribute being equivalent for a given set of one or more operands, a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

76. A method of data storage and/or retrieval system implemented on one or more digital data processing systems, comprising:

20 providing storage media comprising a plurality of data tunnels for each entity type and a fixed plurality of data tunnels for each attribute, one or more of which data tunnels comprise a plurality of data cells, where each of the data cells contain data associated with a respective instance of an

25 attribute for a respective instance of an entity type, where for one or more of the data tunnels, the data cells in each of which have data for which a respective operator evaluates to a boolean result indicating either the likely possibility or the impossibility of a respective instance of an attribute being characterised by said operator for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media, one or more data tunnels based on one or more of said operators and a given set of one or more operands.

77. A data storage and/or retrieval system, comprising

5 storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

10 where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands and where the majority of connective data cells yield a like result for a given set of one or
15 more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

78. A method of data storage and/or retrieval implemented on one or more digital data
20 processing systems, comprising

providing storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

25 where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean

result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands, accessing, with a storage engine that is in communications coupling with the storage media, one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

79. A data storage and/or retrieval system, comprising

storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,

where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

80. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

providing storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,

where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,

5 accessing, with a storage engine that is in communications coupling with the storage media, one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

81. A data storage and/or retrieval system, comprising

10 providing storage media comprising a plurality of characteristic data tunnels for each entity type and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

15 in which each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute possessing a property for a given set of one or more operands,

20

accessing, with a storage engine that is in communications coupling with the storage media, one or more characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

25 82. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

providing storage media comprising a plurality of characteristic data tunnels for each entity type and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

30 where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a
 5 boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute possessing a property for a given set of one or more operands,

accessing, with a storage engine that is in communications coupling with the storage media. one or more characteristic data tunnels based on one or more of said possessive
 10 operator and a given set of one or more operands.

83. A method data storage and/or retrieval, comprising

providing storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,

15 where each collective data tunnel contains data associated with a respective instance of an entity type.

where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

20 where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

84. A method data storage and/or retrieval, comprising

providing storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,

25 where each collective data tunnel contains data associated with a respective instance of an entity type.

where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

85. A method according to any of Claims 76, 78, 80 and 82 to 84, in which

the connective data cell contains a digest of the respective instance of the attribute,

5 the respective connective data tunnel is chosen from a defined hash encoding of the respective instance of the attribute and by applying a modulo of the number of the plurality of connective data tunnels to said hash encoding.

86. A method according to Claim 85, in which the digest of the respective instance of the attribute is the value of the respective instance itself when the size of the respective instance is
10 sufficiently small, whereby the equivalence operator can be certain of equivalence.

87. A method according to any of Claims 76, 78, 80 and 82 to 84, in which

each instance of a respective attribute is expressed in unitary scale and as a significand with respect to a fixed radix point,

each combinative data tunnels is respective to part of the said significand,

15 all combinative data tunnels are mutually exclusive in respect of the said significand

all combinative data tunnels enclose the whole of the said significand

88. A method according to Claim 87, the further improvement for the evaluation of a bounding operator during the read access of said combinative tunnels of said attribute of said storage system, comprising the steps of

20 converting each respective boundary operand in the said bounding operator to a significand of unitary scale with a fixed radix point;

comparing the significand bits of respective boundary operands in descending significance order to find the first significand bit that differs between said operands and taking all prior common bits as a determinant data value;

25 finding the combinative data tunnel of lowest significance that comprises a strict subset of the significance of said determinant value and taking said combinative data tunnel as the determinant data tunnel;

accessing the said determinant data tunnel first before other combinative data tunnels respective of said attribute;

inspecting all combinative data cells of said determinant data tunnel and deeming the relevance of each respective entity instance as impossible for said bounding operator

5

where said combinative data cell is not equal to the said determinant data value;

whereby only combinative data cells, respective of entity instances not deemed of impossible relevance, in combinative data tunnels other than said determinant data tunnel need be inspected for the purposes of determining relevance of respective entity instances to the respective bounding operator and its respective operands.

10

89. A method according to any of Claims 76, 78, 80 and 82 to 84, in which

each characteristic data tunnel is respective of one or more properties.

a characteristic data cell contains a boolean indication of possession of a respective property by the respective instance of the attribute,

15

90. A method according to Claim 89, in which a characteristic tunnel is chosen to be respective of a property by hash encoding the property identity and applying a modulo of the number of plurality of characteristic data tunnels to said hash encoding.

20

91. A method according to Claim 89, in which a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 83T$ where P is the ordinal of the property; M is the maximum ordinal assigned and T is the number of characteristic tunnels.

25

92. A method according to Claim 89, in which a characteristic tunnel is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity for the respective attribute and applying a modulo of the number of plurality characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 83T$ where P is the ordinal of the property; M is the maximum ordinal assigned for the respective attribute and T is the number of characteristic tunnels.

93. A data storage storage and/or retrieval according to any of Claims 76, 78, 80 and 82 to 84, in which a collective data cell characterised as one of identity comprises of a sequence of bits that denote the identity such that certainty of equivalence of identity for the respective instance of the respective attribute can be determined by comparison of said bits in like sequence order.

94. A method according to Claim 92, in which a collective data cell characterised as one of measurement comprises of a sign bit, a plurality of significand bits and a plurality of exponent bits such that certainty of a respective instance of the respective attribute being bounded by a range can be determined by comparison of the respective sign, significand and exponent bits.

95. A method according to Claim 92, in which a collective data cell characterised as one of enumeration comprises of a plurality of properties in which each property is comprised of a sequence of bits such that certainty of possession of a property by the respective instance of the respective attribute can be determined by a comparison of said bits in like sequence order for one or more respective properties.

96. A method according to Claim 92, in which each data tunnel is individually encrypted during write access to storage and individually decrypted during read access from storage.

97. A method according to Claim 92, in which each data cell is individually encrypted during write access to storage and individually decrypted during read access from storage.

98. A method according to any of Claims 76, 78, 80 and 82 to 84 and/or Claim 92, in which a specific set of one or more tunnels are accessed for each of the said operators and their respective operands, that comprise a query.

99. A method according to Claim 98, in which one or more data tunnels are accessed independently and simultaneously for the evaluation of each said operators and their respective operands

100. A method according to Claim 98, in which each operator evaluation includes a boolean indication of certainty or uncertainty for each respective instance deemed likely possible.

101. A method according to Claim 100, in which operator evaluations are combined conjunctively for a common respective entity type such that some uncertain respective entity instances may be discarded from operator evaluations.

5 102. A method according to Claim 100, in which subsequent materialisation of an operator evaluation can resolve any uncertainty by inspecting the respective collective data cell for the respective instance of an attribute deemed uncertain.

103. A method according to Claim 98, in which data tunnels are read accessed in bulk from storage media for the evaluation of each said operators and their respective operands

10 104. A method according to any of Claims 76, 78, 80 and 82 to 84, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective data cells in corresponding data tunnels.

105. A method according to any of Claims 76, 78, 80 and 82 to 84, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective connective data cells in corresponding connective data tunnels.

15 106. A method according to any of Claims 76, 78, 80 and 82 to 84, in which a plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.

107. A method according to Claim 106, in which a plurality of connective data tunnels and respective operators relate to instances of entities of arbitrary structure.

20 108. A method according to Claim 106, in which a plurality of combinative data tunnels and respective operators relate to instances of entities of arbitrary structure.

109. A method according to Claim 106, in which a plurality of characteristic data tunnels and respective operators relate to instances of entities of arbitrary structure.

25 110. A method according to Claim 106, in which a plurality of data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

111. A method according to Claim 110, in which a plurality of connective data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

112. A method according to Claim 110, in which a plurality of combinative data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

5 113. A method according to Claim 110, in which a plurality of characteristic data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

114. A method according to any of Claims 76, 78, 80 and 82 to 84, in which data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

10 115. A method according to Claim 114, in which connective data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

116. A method according to Claim 114, in which combinative data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct
15 instances of said attribute may differ in domain or encoding.

117. A method according to Claim 114, in which characteristic data cells consist of data independent of the domain and the encoding for the respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

20 118. A method according to any of Claims 76, 78, 80 and 82 to 84, the further improvement for discerning from a database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of

discerning an applicability of an equivalence operator from relationship constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

25 discerning the applicability of a bounding operator from the numerical or time domain or arithmetic domain constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

discerning the applicability of a possessive operator from the character domain or enumeration domain constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute;

5 discerning the inapplicability of said operators from the object or binary domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.

119. A method according to Claim 118, whereby the further improvement for discerning
10 from a relational database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of

discerning an applicability of an equivalence operator from primary key and foreign key constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

15 discerning the applicability of a bounding operator from the numerical or time domain or arithmetic check constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

20 discerning the applicability of a possessive operator from the character domain or enumeration check constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute;

25 discerning the inapplicability of said operators from the large object domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.

120. A method according to any of Claims 76, 78, 80 and 82 to 84 and/or Claim 92, the further improvement for accessing data tunnels for the purpose of materialising a query result, comprising the steps of

re-factoring the query expression to produce a disjunctive normal form expression of operators and their respective operands;

removing each operator and respective operands from each conjunctive term of said disjunctive normal form expression where the outcome of said operator is implied by one or more other operators in the same said conjunctive term;

removing each conjunctive term from said disjunctive normal form expression where said conjunctive term contains an operator and respective operands that is deemed to be always false;

evaluating each operator of said disjunctive normal form expression where said operator is respective of a single entity type to produce a separate relevant set of entity instances for each said operator independently and simultaneously for each said operator, for storage in computer memory;

reducing said relevant sets of entity instances where said sets are respective of a common entity type such that members of said sets not respective to every said set for said entity are discarded to produce a common set of entity instances for said entity type independently and simultaneously for each respective entity type in each conjunctive term of said disjunctive normal form, for storage in computer memory;

correlating said common sets of entity instances for said entity types paired by binding operators in a sequence to produce a correlated set of entity instances for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

accessing data tunnels respective to each said correlated set of entity instances to produce a set of query result instances independently and separately for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

marking query result instances as void where query result instances conflict with the respective conjunctive term independently and simultaneously for each said conjunctive term, for storage in computer memory;

merging said sets of query result instances for each said conjunctive term such that respective query result instances from each said set are combined into a single set of query result instances, for storage in computer memory;

121. A method according to Claim 120, the further improvement for correlating said common sets of entity instances within said conjunctive term for the purpose of producing a correlated set of entity instances, comprising the steps of

correlating pairs of common sets of entity instances across a mutually respective bind operator in a defined visit sequence of bind operators, for storage in memory;

updating the cardinality of entity instances in respective correlated sets of entity instances in reverse order of said visit sequence, for storage in memory.

122. A method according to Claim 121 the further improvement for deciding said visit sequence of said bind operators with said conjunctive term, comprising the steps of

selecting a common set of entity instances with the least number of respective entity instances within said conjunctive term as the origin set of entity instances;

selecting one of the said bind operators respective to the said origin set of entity instances as the first bind operator in the said visit sequence;

selecting a subsequent bind operator from those bind operators respective to the same common set of entity instances as the bind operator most recently visited and which have not appeared in the said visit sequence or which have already appeared in said visit sequence but have been affected by a bind operator subsequently visited;

repeating the prior step until no more bind operators are available to be selected; such that correlated sets of entity instances are produced in the said visit sequence for storage in computer memory.

123. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

storage media comprising a plurality of data segments for each instance of an entity type manipulated by a database operation in a respective database transaction

where all data segments are maintained within a contiguous data heap of arbitrary size; where all new data segments are appended to the data heap and assigned to respective transactions and respective entity instances in arbitrary order;

a storage engine that is in communications coupling with the storage media and writes said data heap to storage media in a minimal number of storage write operations when any one of said transactions commits its state.

124. A method according to Claim 123, in which storage write operations are performed such that all said data segments within said data heap are written to storage in a minimum of storage write requests.

125. A method according to Claim 123, in which storage write operations for said data heap only occur at predefined regular intervals, such that transactions committing their state cannot complete said commit until the next storage write operation for said data heap has successfully completed.

126. A method according to any of Claims 76, 78, 80 and 82 to 84 and/or Claim 123, in which

an instance of a entity type is logically deleted by appending an inversion of the respective instance,

the said inversion appears identical to the respective instance in all respective connective, combinative and characteristic data tunnels;

a single inversion data tunnel for each entity type contains a plurality of data cells in which a data cell denotes an inversion of a respective instance of said entity type.

127. A method according to Claim 126, in which

append access to data tunnels and data heaps occurs in chronological order,

read access to data tunnels and data heaps occurs in reverse chronological order

read access resolves entity instance inversion by accumulating inversions and discounting corresponding entity instances as they are encountered.

128. The method of data storage and/or retrieval according to any of Claims 76, 78, 80 and 82 to 84, in which a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of their respective entity instances.

129. The method of data storage and/or retrieval according to Claim 128, in which a plurality of the cells of at least one said tunnel are grouped in frames based on common

characteristics of the respective entity instances such that cells across all tunnels respect common frame boundaries.

130. The method of data storage and/or retrieval according to Claim 129, in which said common characteristic is time period.

5 131. The method of data storage and/or retrieval according to Claim 130, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media with respect to the age of the data retained.

132. The method of data storage and/or retrieval according to Claim 130, comprising a database engine that is coupled to the storage engine and that eliminates frames from read
10 access during a query with respect to a time threshold expressed within said query.

133. The method of data storage and/or retrieval according to Claim 129, in which said common characteristic is volume of respective entity instances

134. The method of data storage and/or retrieval according to Claim 133, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in
15 the storage media with respect to the volume of the data retained.

135. The method of data storage and/or retrieval according to Claim 129, in which a plurality of data cells respective of a plurality of data tunnels respective of a plurality of frames are accumulated within a single logical storage system file of a plurality of logical storage system files.

20 136. The method of data storage and/or retrieval according to Claim 129, comprising a database engine that is coupled to the storage engine and that manages a retention of cells in the storage media.

137. The method of data storage and/or retrieval according to Claim 128, in which a common characterisation of respective cells within a plurality of frames is maintained across a
25 plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective operator and its operands.

138. The method of data storage and/or retrieval according to Claim 137, in which a plurality of bit sequences common to all respective instances of attributes for data cells within

a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective equivalence operator and its operands.

139. The method of data storage and/or retrieval according to Claim 137, in which bounds
5 common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective bounding operator and its operands.

140. The method of data storage and/or retrieval according to Claim 137, in which
10 properties common to all respective instances of attributes for data cells within a plurality of frames is maintained across a plurality of frame intervals and across a plurality of frame interval sizes whereby a plurality of frames and respective data cells may be eliminated from consideration by a respective possessive operator and its operands.

141. The method of data storage and/or retrieval according to Claim 123, in which a
15 plurality of said data segments are grouped in frames based on common characteristics of their respective entity instances.

142. The method of data storage and/or retrieval according to Claim 141, in which said common characteristic is time period.

143. The method of data storage and/or retrieval according to Claim 141, in which said
20 common characteristic is volume of respective entity instances.

144. The method of data storage and/or retrieval according to Claim 141, comprising a storage engine that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame.

145. The method of data storage and/or retrieval according to Claim 144, comprising a
25 storage engine and that appends data cells to respective data tunnels for instances of respective entities contained in data segments that comprise a complete frame, as and when each frame becomes complete.

146. The method of data storage and/or retrieval according to Claim 144, comprising a storage engine and that appends data cells to respective data tunnels for instances of respective

entities contained in data segments that comprise a plurality of complete frames, as and when said plurality of frames become complete.

147. A method according to Claim 144, the further improvement for resolution of duplicate entity instances during query access of said storage system, comprising the steps of

5 assigning said frames of the data storage system according to Claim 141 in identical manner to that used for the data storage system according to Claim 128;

accessing said frames of the data storage system according to Claim 141 prior to accessing said frames of the data storage system according to Claim 128 during said query access;

10 discounting any said frames in the data storage system according to Claim 128 that correspond to said frames accessed in the data storage system according to Claim 141 during said query access; such that each entity instance can be persisted in the data storage system according to Claim 141 and in the data storage system according to Claim 128 at the same time to ensure persistence of said entity instances without
15 affecting the result of said query access.

148. The method of data storage and/or retrieval according to any of Claims 76, 78, 80 and 82 to 84 and/or Claim 92, in which a complete definition of respective entity types and respective attributes is stored within distinct storage system file identified by a unique version identity whenever said definition is changed.

20 149. The method of data storage and/or retrieval according to Claim 148, in which each distinct entity type definition is assigned a unique ordinal identity from a single monotonically increasing ordinal number sequence.

150. The method of data storage and/or retrieval according to Claim 148, in which each distinct attribute definition is assigned a unique ordinal identity from a monotonically
25 increasing ordinal number sequence for the respective entity type.

151. The method of data storage and/or retrieval according to Claim 148, in which each complete definition is assigned a unique version identity from a single monotonically increasing version number sequence.

152. The method of data storage and/or retrieval according to Claim 148 and/or Claim 128, in which each complete definition is assigned the identity of the respective frame in which said definition is created.

5 153. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81 comprising

storage media comprising a plurality of connective data tunnels for each entity type and a fixed plurality of connective data tunnels for each attribute, one or more of which connective data tunnels comprise a plurality of connective data cells,

10 where each of the connective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

15 where for one or more of the connective data tunnels, the connective data cells in each of which have data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of a respective instance of an attribute being equivalent for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

20 154. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, comprising

storage media comprising a plurality of combinative data tunnels for each entity type and a fixed plurality of combinative data tunnels for each attribute, one or more of which data tunnels comprise a plurality of combinative data cells,

25 where each of the combinative data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

where for one or more of the combinative data tunnels, the combinative cells in each of which have data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a respective instance of an attribute being bounded for a given set of one or more operands,

5 a storage engine that is in communications coupling with the storage media and that accesses one or more combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

155. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, comprising

10 storage media comprising a plurality of characteristic data tunnels for each entity type and a fixed plurality of characteristic data tunnels for each attribute, one or more of which characteristic data tunnels comprise a plurality of data cells,

where each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

15 in which each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

where for one or more of the characteristic data tunnels, the characteristic data cells in each of which have data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of a
20 respective instance of an attribute possessing a property for a given set of one or more operands,

a storage engine that is in communications coupling with the storage media and that accesses one or more characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

25 156. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, comprising

storage media comprising a plurality of collective data tunnels for each entity type, one or more of which collective data tunnels comprise a plurality of collective data cells,

where each collective data tunnel contains data associated with a respective instance of
30 an entity type.

where each of the collective data cells contain data associated with a respective instance of an attribute for a respective instance of an entity type,

where each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

5 157. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, in which a specific set of one or more tunnels are accessed for each of the said operators and their respective operands, that comprise a query.

158. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, in which distinct attributes may be correlated by the equivalence of their respective
10 instances by comparison of their respective data cells in corresponding data tunnels.

159. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective connective data cells in corresponding connective data tunnels.

15 160. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, in which a plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.

161. A data storage and/or retrieval system according to any of Claim 45, 75, 76, 77, 79 and 81, in which data cells consist of data independent of the domain and the encoding for the
20 respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

162. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79 and 81, the further improvement for discerning from a database schema the operators and respective data tunnels that are applicable to a respective attribute, comprising the steps of

25 discerning an applicability of an equivalence operator from relationship constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

discerning the applicability of a bounding operator from the numerical or time domain or arithmetic domain constraints for said attribute such that data for instances of said

attribute are stored in combinative data cells within combinative data tunnels
respective of said attribute;

discerning the applicability of a possessive operator from the character domain or
enumeration domain constraints for said attribute such that data for instances of said
5 attribute are stored in characteristic data cells within characteristic data tunnels
respective of said attribute;

discerning the inapplicability of said operators from the object or binary domain or
external reference for said attribute such that data for instances of said attribute are not
stored in any connective, combinative or characteristic data tunnels respective of said
10 attribute.

163. A data storage and/or retrieval system according to any of Claims 45, 75, 76, 77, 79
and 81, the further improvement for accessing data tunnels for the purpose of materialising a
query result, comprising the steps of

re-factoring the query expression to produce a disjunctive normal form expression of
15 operators and their respective operands;

removing each operator and respective operands from each conjunctive term of said
disjunctive normal form expression where the outcome of said operator is implied by
one or more other operators in the same said conjunctive term;

removing each conjunctive term from said disjunctive normal form expression where
20 said conjunctive term contains an operator and respective operands that is deemed to
be always false;

evaluating each operator of said disjunctive normal form expression where said
operator is respective of a single entity type to produce a separate relevant set of entity
instances for each said operator independently and simultaneously for each said
25 operator, for storage in computer memory;

reducing said relevant sets of entity instances where said sets are respective of a
common entity type such that members of said sets not respective to every said set for
said entity are discarded to produce a common set of entity instances for said entity
type independently and simultaneously for each respective entity type in each
30 conjunctive term of said disjunctive normal form, for storage in computer memory;

correlating said common sets of entity instances for said entity types paired by binding operators in a sequence to produce a correlated set of entity instances for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

5 accessing data tunnels respective to each said correlated set of entity instances to produce a set of query result instances independently and separately for each respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

10 marking query result instances as void where query result instances conflict with the respective conjunctive term independently and simultaneously for each said conjunctive term, for storage in computer memory;

merging said sets of query result instances for each said conjunctive term such that respective query result instances from each said set are combined into a single set of query result instances, for storage in computer memory;

15 164. A data storage and/or retrieval system according to any of Claims 75, 76, 77, 79 and 81, in which storage write operations are performed such that all said data segments within said data heap are written to storage in a minimum of storage write requests.

20 165. A data storage and/or retrieval system according to any of Claims 75, 76, 77, 79 and 81, in which storage write operations for said data heap only occur at predefined regular intervals, such that transactions committing their state cannot complete said commit until the next storage write operation for said data heap has successfully completed.

166. A data storage and/or retrieval system according to any of Claims 75, 76, 77, 79 and 81, in which

25 an instance of a entity type is logically deleted by appending an inversion of the respective instance,

the said inversion appears identical to the respective instance in all respective connective, combinative and characteristic data tunnels;

a single inversion data tunnel for each entity type contains a plurality of data cells in which a data cell denotes an inversion of a respective instance of said entity type.

167. A data storage and/or retrieval system according to any of Claims 75, 76, 77, 79 and 81, in which a plurality of the cells of at least one said tunnel are grouped in frames based on common characteristics of their respective entity instances.

5 168. A data storage and/or retrieval system according to any of Claims 75, 76, 77, 79 and 81, in which a plurality of said data segments are grouped in frames based on common characteristics of their respective entity instances.

169. A data storage and/or retrieval system according to any of Claims 75, 76, 77, 79 and 81, in which a complete definition of respective entity types and respective attributes is stored within distinct storage system file identified by a unique version identity whenever said
10 definition is changed.

170. A data storage and/or retrieval system implemented on one or more digital data processing systems, comprising:

15 storage media comprising a plurality of data tunnels, one or more of said plurality of data tunnels having a plurality of data cells, in which the plurality of data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of data tunnels for each attribute is fixed for a given attribute,
in which each of the data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,
20 in which each of the data cells of the plurality of attribute data tunnels has data for which a respective operator evaluates to a boolean result indicating either the likely possibility or the impossibility of the attribute instance corresponding to said data cell being characterised by said operator for a given set of one or more operands, and
a storage engine that is in communications coupling with the storage media and that
25 accesses one or more of the plurality of data tunnels based on one or more of said operators and a given set of one or more operands.

171. A data storage and/or retrieval system according to Claim 170,

in which the plurality of entity type data tunnels comprise a plurality of connective data tunnels, the plurality of attribute data tunnels comprise a plurality of connective

data tunnels, and the plurality of data cells of said connective data tunnels are connective data cells,

in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

5 in which each of the connective data cells has data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said connective data cell being equivalent for a given set of one or more operands, and

10 in which the storage engine accesses one or more of the plurality of connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

172. A data storage and/or retrieval system according to Claim 171, in which

the majority of the connective data cells yield a like result for a given set of one or more operands.

15 173. A data storage and/or retrieval system according to Claim 172, in which:

each of the connective data cells contains a digest of the attribute instance corresponding to said connective data cell, and

20 the respective connective data tunnel for each instance of an attribute is chosen from a defined hash encoding of the respective instance of the attribute and by applying a modulo of the number of the plurality of connective data tunnels to said hash encoding.

174. A data storage and/or retrieval system according to Claim 173, in which the digest is the value of the attribute instance corresponding to said connective data cell when the size of said attribute instance is sufficiently small, whereby the equivalence operator can be certain of
25 equivalence.

175. A data storage and/or retrieval system according to Claim 170,

in which the plurality of entity type data tunnels comprise a plurality of combinative data tunnels, the plurality of attribute data tunnels comprise a plurality of combinative

data tunnels, and the plurality of data cells of said combinative data tunnels are combinative data cells,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

5 in which each of the combinative data cells has data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said combinative data cell being bounded for a given set of one or more operands, and

10 in which the storage engine accesses one or more of the plurality of combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

176. A data storage and/or retrieval system according to Claim 175, in which

each instance of a respective attribute is expressed in unitary scale and as a significand with respect to a fixed radix point,

15 each of the combinative data tunnels is respective to part of the significand,

all of the combinative data tunnels are mutually exclusive in respect of the significand, and

all of the combinative data tunnels enclose the whole of the significand.

177. A data storage and/or retrieval system according to Claim 170,

20 in which the plurality of entity type data tunnels comprise a plurality of characteristic data tunnels, the plurality of attribute data tunnels comprise a plurality of characteristic data tunnels, and the plurality of data cells of said characteristic data tunnels are characteristic data cells,

25 in which each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

in which each of the characteristic data cells has data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said characteristic data cell possessing a property for a given set of one or more operands, and

in which the storage engine accesses one or more of the plurality of characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

178. A data storage and/or retrieval system according to Claim 177, in which:

5 each of the characteristic data tunnels is respective of one or more properties, and each of the characteristic data cells contains a boolean indication of possession of a respective property by the attribute instance corresponding to said characteristic data cell.

179. A data storage and/or retrieval system according to Claim 178, in which each of the
10 characteristic data tunnels is chosen to be respective of a property by hash encoding the property identity and applying a modulo of the number of the plurality of characteristic data tunnels to said hash encoding.

180. A data storage and/or retrieval system according to Claim 178, in which each of the
15 characteristic data tunnels is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity and applying a modulo of the number of the plurality of characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned; and T is the number of characteristic data tunnels.

20 181. A data storage and/or retrieval system according to Claim 178, in which each of the characteristic data tunnels is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity for the respective attribute and applying a modulo of the number of the plurality of characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$
25 where P is the ordinal of the property; M is the maximum ordinal assigned for the respective attribute; and T is the number of characteristic data tunnels.

182. A data storage and/or retrieval system according to Claim 170,

in which the plurality of entity type data tunnels comprise a plurality of collective data tunnels, the plurality of attribute data tunnels comprise a plurality of collective data

tunnels, and the plurality of data cells of said collective data tunnels are collective data cell,

in which each of the collective data cells contain data which is characterised as one of identity, measurement, enumeration or opacity.

5 183. The data storage and/or retrieval according to Claim 182, in which a collective data cell characterised as one of identity comprises a sequence of bits that denote an identity such that certainty of equivalence of identity for the attribute instance corresponding to said collective data cell can be determined by comparison of said bits in like sequence order.

10 184. A data storage and/or retrieval system according to Claim 182, in which a collective data cell characterised as one of measurement comprises a sign bit, a plurality of significand bits and a plurality of exponent bits such that certainty of the attribute instance corresponding to said collective data cell being bounded by a range can be determined by comparison of the respective sign, significand and exponent bits.

15 185. A data storage and/or retrieval system according to Claim 182, in which a collective data cell characterised as one of enumeration comprises a plurality of properties, in which each property comprises a sequence of bits such that certainty of possession of a property by the attribute instance corresponding to said collective data cell can be determined by a comparison of said bits in like sequence order for one or more respective properties.

20 186. A data storage and/or retrieval system according to Claim 182, in which each of the plurality of data tunnels is individually encrypted during write access to the storage media and individually decrypted during read access from the storage media.

187. A data storage and/or retrieval system according to Claim 182, in which each of the plurality of data cells is individually encrypted during write access to the storage media and individually decrypted during read access from the storage media.

25 188. A data storage and/or retrieval system implemented on one or more digital data processing systems, comprising:

storage media comprising a plurality of connective data tunnels, one or more of said plurality of connective data tunnels having a plurality of connective data cells, in which the plurality of connective data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels

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for each of a plurality of attributes, in which a number of connective data tunnels for each attribute is fixed for a given attribute,

in which each of the connective data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

5 in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

in which each of the connective data cells of the plurality of attribute tunnels has data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance
10 corresponding to said data cell being equivalent for a given set of one or more operands, and

a storage engine that is in communications coupling with the storage media and that accesses one or more of the plurality of connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

15 189. A data storage and/or retrieval system according to Claim 170, in which a specific set of one or more data tunnels are accessed for each of the said operators and their respective operands, that comprise a query.

190. A data storage and/or retrieval system according to Claim 189, in which one or more data tunnels are accessed independently and simultaneously for the evaluation of each said
20 operators and their respective operands.

191. A data storage and/or retrieval system according to Claim 189, in which each of a plurality of operator evaluations includes a boolean indication of certainty or uncertainty for each respective attribute instance deemed likely possible.

192. A data storage and/or retrieval system according to Claim 191, in which operator
25 evaluations are combined conjunctively for a common respective entity type such that some uncertain respective entity instances may be discarded from operator evaluations.

193. A data storage and/or retrieval system according to Claim 191, in which subsequent materialisation of an operator evaluation can resolve any uncertainty by inspecting a respective collective data cell for a respective instance of an attribute deemed uncertain.

194. A data storage and/or retrieval system according to Claim 191, in which data tunnels are read accessed in bulk from the storage media for the evaluation of each of said operators and their respective operands.

5 195. A data storage and/or retrieval system according to Claim 170, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective data cells in corresponding data tunnels.

196. A data storage and/or retrieval system according to Claim 170, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective connective data cells in corresponding connective data tunnels.

10 197. A data storage and/or retrieval system according to Claim 170, in which the plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.

198. A data storage and/or retrieval system according to Claim 197, in which a plurality of the data tunnels are connective data tunnels, and the plurality of connective data tunnels and respective operators relate to instances of entities of arbitrary structure.

15 199. A data storage and/or retrieval system according to Claim 197, in which a plurality of the data tunnels are combinative data tunnels, and the plurality of combinative data tunnels and respective operators relate to instances of entities of arbitrary structure.

200. A data storage and/or retrieval system according to Claim 197, in which a plurality of the data tunnels are characteristic data tunnels, and the plurality of characteristic data tunnels
20 and respective operators relate to instances of entities of arbitrary structure.

201. A data storage and/or retrieval system according to Claim 197, in which the plurality of data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

202. A data storage and/or retrieval system according to Claim 201, in which a plurality of
25 the data tunnels are connective data tunnels, and the plurality of connective data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

203. A data storage and/or retrieval system according to Claim 201, in which a plurality of the data tunnels are combinative data tunnels, and the plurality of combinative data tunnels

and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

204. A data storage and/or retrieval system according to Claim 201, in which a plurality of the data tunnels are characteristic data tunnels, and the plurality of characteristic data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

205. A data storage and/or retrieval system according to Claim 170, in which the plurality of data cells of the plurality of attribute data tunnels consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

206. A data storage and/or retrieval system according to Claim 205, in which the plurality of data cells of the plurality of attribute data tunnels are connective data cells, and the connective data cells consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

207. A data storage and/or retrieval system according to Claim 205, in which the plurality of data cells of the plurality of attribute data tunnels are combinative data cells, and the combinative data cells consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

208. A data storage and/or retrieval system according to Claim 205, in which the plurality of data cells of the plurality of attribute data tunnels are characteristic data cells, and the characteristic data cells consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

209. A data storage and/or retrieval system according to Claim 170, in which

the plurality of data tunnels are connective data tunnels and the plurality of data cells are connective data cells,

each of the connective data cells of the plurality of attribute data tunnels has data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of the attribute instance corresponding to said data cell being equivalent for a given set of one or more operands and where the majority of connective data cells yield a like result for a given set of one or more operands, and

the storage engine accesses one or more of the plurality of connective data tunnels based on one or more of said equivalence operator and a given set of one or more operands.

210. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising:

providing storage media comprising a plurality of data tunnels, one or more of said plurality of data tunnels having a plurality of data cells, in which the plurality of data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of data tunnels for each attribute is fixed for a given attribute,

in which each of the data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

in which each of the data cells of the plurality of attribute data tunnels has data for which a respective operator evaluates to a boolean result indicating either the likely possibility or the impossibility of the attribute instance corresponding to said data cell being characterised by said operator for a given set of one or more operands, and

accessing, with a storage engine that is in communications coupling with the storage media, one or more of the plurality of data tunnels based on one or more of said operators and a given set of one or more operands.

211. A method according to Claim 210, in which

the plurality of data cells include a connective data cell that contains a digest of the attribute instance corresponding to said connective data cell,

the plurality of data tunnels include a plurality of connective data tunnels, which include a respective connective data tunnel that is chosen from a defined hash

encoding of the attribute instance corresponding to said connective data cell and by applying a modulo of the number of the plurality of connective data tunnels to said hash encoding.

212. A method according to Claim 211, in which the digest of the attribute instance corresponding to said connective data cell is the value of the attribute instance itself when the size of the attribute instance is sufficiently small, whereby the equivalence operator can be certain of equivalence.

213. A method according to Claim 210, in which

each instance of a respective attribute is expressed in unitary scale and as a significand with respect to a fixed radix point,

each of a plurality of combinative data tunnels is respective to part of the significand,

all of the combinative data tunnels are mutually exclusive in respect of the significand

all of the combinative data tunnels enclose the whole of the significand

214. A method according to Claim 213, further comprising, for the evaluation of a bounding operator during read access of said combinative data tunnels, the steps of:

converting each respective boundary operand in the bounding operator to a significand of unitary scale with a fixed radix point;

comparing the significand bits of respective boundary operands in descending significance order to find the first significand bit that differs between said operands and taking all prior common bits as a determinant data value;

finding the combinative data tunnel of lowest significance that comprises a strict subset of the significance of said determinant value and taking said combinative data tunnel as the determinant data tunnel;

accessing the determinant data tunnel first before other combinative data tunnels respective of said attribute;

inspecting all combinative data cells of said determinant data tunnel and deeming the relevance of each respective entity instance as impossible for said bounding operator where said combinative data cell is not equal to the said determinant data value; whereby only combinative data cells, respective of entity instances not deemed of

impossible relevance, in combinative data tunnels other than said determinant data tunnel need be inspected for the purposes of determining relevance of respective entity instances to the respective bounding operator and its respective operands.

215. A method according to Claim 210, in which

5 each of a plurality of characteristic data tunnels is respective of one or more properties, and

a characteristic data cell of said characteristic data tunnels contains a boolean indication of possession of a respective property by the attribute instance corresponding to said characteristic data cell,

10 216. A method according to Claim 215, in which each of the characteristic data tunnels is chosen to be respective of a property by hash encoding the property identity and applying a modulo of the number of the plurality of characteristic data tunnels to said hash encoding.

217. A method according to Claim 215, in which each of the characteristic data tunnels is chosen to be respective of a property by assigning a strictly monotonically increasing ordinal
15 to each unique property identity and applying a modulo of the number of the plurality of characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned; and T is the number of characteristic data tunnels.

218. A method according to Claim 215, in which each of the characteristic data tunnels is
20 chosen to be respective of a property by assigning a strictly monotonically increasing ordinal to each unique property identity for the respective attribute and applying a modulo of the number of the plurality of characteristic data tunnels to said ordinal; whereby the possessive operator can be certain of possession if $(M - T) < P < 2T$ where P is the ordinal of the property; M is the maximum ordinal assigned for the respective attribute; and T is the number
25 of characteristic data tunnels.

219. A method according to Claim 210, in which the plurality of data cells include a plurality of collective data cells, and in which a collective data cell characterised as one of identity comprises a sequence of bits that denote an identity such that certainty of equivalence of identity for the attribute instance corresponding to said collective data cell can be
30 determined by comparison of said bits in like sequence order.

220. A method according to Claim 210, in which the plurality of data cells include a plurality of collective data cells, and in which a collective data cell characterised as one of measurement comprises a sign bit, a plurality of significand bits and a plurality of exponent bits such that certainty of the attribute instance corresponding to said collective data cell
5 bounded by a range can be determined by comparison of the respective sign, significand and exponent bits.

221. A method according to Claim 210, in which the plurality of data cells include a plurality of collective data cells, and in which a collective data cell characterised as one of enumeration comprises a plurality of properties, in which each property comprises a sequence
10 of bits such that certainty of possession of a property by the attribute instance corresponding to said collective data cell can be determined by a comparison of said bits in like sequence order for one or more respective properties.

222. A method according to Claim 210, in which each of the plurality of data tunnels is individually encrypted during write access to the storage media and individually decrypted
15 during read access from the storage media.

223. A method according to Claim 210, in which each of the plurality of data cells is individually encrypted during write access to the storage media and individually decrypted during read access from the storage media.

224. A method according to Claim 210, in which a specific set of one or more data tunnels
20 are accessed for each of the said operators and their respective operands, that comprise a query.

225. A method according to Claim 224, in which one or more data tunnels are accessed independently and simultaneously for the evaluation of each said operators and their respective operands

226. A method according to Claim 224, in which each of a plurality of operator evaluations
25 includes a boolean indication of certainty or uncertainty for each respective attribute instance deemed likely possible.

227. A method according to Claim 226, in which operator evaluations are combined conjunctively for a common respective entity type such that some uncertain respective entity
30 instances may be discarded from operator evaluations.

228. A method according to Claim 226, in which subsequent materialisation of an operator evaluation can resolve any uncertainty by inspecting a respective collective data cell for a respective instance of an attribute deemed uncertain.

5 229. A method according to Claim 224, in which data tunnels are read accessed in bulk from the storage media for the evaluation of each of said operators and their respective operands

230. A method according to Claim 210, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective data cells in corresponding data tunnels.

10 231. A method according to Claim 210, in which distinct attributes may be correlated by the equivalence of their respective instances by comparison of their respective connective data cells in corresponding connective data tunnels.

232. A method according to Claim 210, in which the plurality of data tunnels and respective operators relate to instances of entities of arbitrary structure.

15 233. A method according to Claim 232, in which a plurality of the data tunnels are connective data tunnels, and the plurality of connective data tunnels and respective operators relate to instances of entities of arbitrary structure.

20 234. A method according to Claim 232, in which a plurality of the data tunnels are combinative data tunnels, and the plurality of combinative data tunnels and respective operators relate to instances of entities of arbitrary structure.

235. A method according to Claim 232, in which a plurality of the data tunnels are characteristic data tunnels, and the plurality of characteristic data tunnels and respective operators relate to instances of entities of arbitrary structure.

25 236. A method according to Claim 232, in which the plurality of data tunnels and respective operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

237. A method according to Claim 236, in which a plurality of the data tunnels are connective data tunnels, and the plurality of connective data tunnels and respective operators

relate to instances of an entity type in which distinct instances of said entity type differ in structure.

238. A method according to Claim 236, in which a plurality of the data tunnels are combinative data tunnels, and the plurality of combinative data tunnels and respective
5 operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

239. A method according to Claim 236, in which a plurality of the data tunnels are characteristic data tunnels, and the plurality of characteristic data tunnels and respective
10 operators relate to instances of an entity type in which distinct instances of said entity type differ in structure.

240. A method according to Claim 210, in which the plurality of data cells of the plurality of attribute data tunnels consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

15 241. A method according to Claim 240, in which the plurality of data cells of the plurality of attribute data tunnels are connective data cells, and the connective data cells consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

20 242. A method according to Claim 240, in which the plurality of data cells of the plurality of attribute data tunnels are combinative data cells, and the combinative data cells consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

25 243. A method according to Claim 240, in which the plurality of data cells of the plurality of attribute data tunnels are characteristic data cells, and the characteristic data cells consist of data independent of the domain and the encoding for their respective attribute whereby distinct instances of said attribute may differ in domain or encoding.

244. A method according to Claim 210, further comprising, for discerning from a database schema the operators and respective data tunnels that are applicable to a respective attribute, the steps of:

discerning an applicability of an equivalence operator from relationship constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

5

discerning the applicability of a bounding operator from the numerical or time domain or arithmetic domain constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

10

discerning the applicability of a possessive operator from the character domain or enumeration domain constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute; and

15

discerning the inapplicability of said operators from the object or binary domain or external reference for said attribute such that data for instances of said attribute are not stored in any connective, combinative or characteristic data tunnels respective of said attribute.

245. A method according to Claim 244, further comprising, for discerning from a relational database schema the operators and respective data tunnels that are applicable to a respective attribute, the steps of:

20

discerning an applicability of an equivalence operator from primary key and foreign key constraints for said attribute such that data for instances of said attribute are stored in connective data cells within connective data tunnels respective of said attribute;

25

discerning the applicability of a bounding operator from the numerical or time domain or arithmetic check constraints for said attribute such that data for instances of said attribute are stored in combinative data cells within combinative data tunnels respective of said attribute;

30

discerning the applicability of a possessive operator from the character domain or enumeration check constraints for said attribute such that data for instances of said attribute are stored in characteristic data cells within characteristic data tunnels respective of said attribute; and

discerning the inapplicability of said operators from the large object domain or external reference for said attribute such that data for instances of said attribute are not

stored in any connective, combinative or characteristic data tunnels respective of said attribute.

246. A method according to Claim 210, further comprising, for accessing data tunnels for the purpose of materialising a query result, the steps of:

- 5 re-factoring the query expression to produce a disjunctive normal form expression of operators and their respective operands;
removing each operator and respective operands from each conjunctive term of said disjunctive normal form expression where the outcome of said operator is implied by one or more other operators in the same said conjunctive term;
- 10 removing each conjunctive term from said disjunctive normal form expression where said conjunctive term contains an operator and respective operands that is deemed to be always false;
evaluating each operator of said disjunctive normal form expression where said operator is respective of a single entity type to produce a separate relevant set of entity
- 15 instances for each said operator independently and simultaneously for each said operator, for storage in computer memory;
reducing said relevant sets of entity instances where said sets are respective of a common entity type such that members of said sets not respective to every said set for said entity are discarded to produce a common set of entity instances for said entity
- 20 type independently and simultaneously for each respective entity type in each conjunctive term of said disjunctive normal form, for storage in computer memory;
correlating said common sets of entity instances for said entity types paired by binding operators in a sequence to produce a correlated set of entity instances for each
- 25 respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;
accessing data tunnels respective to each said correlated set of entity instances to produce a set of query result instances independently and separately for each
- respective entity type independently and simultaneously for each said conjunctive term, for storage in computer memory;

marking query result instances as void where query result instances conflict with the respective conjunctive term independently and simultaneously for each said conjunctive term, for storage in computer memory; and

merging said sets of query result instances for each said conjunctive term such that
 5 respective query result instances from each said set are combined into a single set of query result instances, for storage in computer memory.

247. A method according to Claim 246, further comprising, for correlating said common sets of entity instances within said conjunctive term for the purpose of producing a correlated set of entity instances, the steps of

10 correlating pairs of common sets of entity instances across a mutually respective bind operator in a defined visit sequence of bind operators, for storage in computer memory; and

updating the cardinality of entity instances in respective correlated sets of entity instances in reverse order of said visit sequence, for storage in computer memory.

15 248. A method according to Claim 247, further comprising, for deciding said visit sequence of said bind operators with said conjunctive term, the steps of:

selecting a common set of entity instances with the least number of respective entity instances within said conjunctive term as the origin set of entity instances;

20 selecting one of the said bind operators relative to the said origin set of entity instances as the first bind operator in the said visit sequence;

selecting a subsequent bind operator from those bind operators relative to the same common set of entity instances as the bind operator most recently visited and which have not appeared in the said visit sequence or which have already appeared in said visit sequence but have been affected by a bind operator subsequently visited; and

25 repeating the prior step until no more bind operators are available to be selected; such that correlated sets of entity instances are produced in the said visit sequence for storage in computer memory.

249. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising:

providing storage media comprising a plurality of connective data tunnels, one or more of said plurality of connective data tunnels having a plurality of connective data cells, in which the plurality of connective data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of data tunnels for each attribute is fixed for a given attribute,

in which each of the connective data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

in which each respective instance of an attribute has one respective connective data cell in only one respective connective data tunnel,

in which each of the connective data cells of the plurality of attribute data tunnels has data for which a respective equivalence operator evaluates to a boolean result which indicates either the likely possibility or impossibility of the attribute instance corresponding to said connective data cell being equivalent for a given set of one or more operands, and

accessing, with a storage engine that is in communications coupling with the storage media, one or more of the plurality of connective data tunnels based on one or more of said equivalence operators and a given set of one or more operands.

250. A data storage and/or retrieval system, comprising:

storage media comprising a plurality of combinative data tunnels, one or more of said plurality of combinative data tunnels having a plurality of combinative data cells, in which the plurality of combinative data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of combinative data tunnels for each attribute is fixed for a given attribute,

in which each of the combinative data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

in which each of the combinative data cells of the plurality of attribute data tunnels has data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said combinative data cell being bounded for a given set of one or more operands, and

a storage engine that is in communications coupling with the storage media and that accesses one or more of the plurality of combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

251. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising:

providing storage media comprising a plurality of combinative data tunnels, one or more of said plurality of combinative data tunnels having a plurality of combinative data cells, in which the plurality of combinative data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of combinative data tunnels for each attribute is fixed for a given attribute,

in which each of the combinative data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

in which each respective instance of an attribute has one respective combinative data cell in all respective combinative data tunnels,

in which each of the combinative data cells of the plurality of attribute data tunnels has data for which a respective bounding operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said combinative data cell being bounded for a given set of one or more operands, and

accessing, with a storage engine that is in communications coupling with the storage media, one or more of the plurality of combinative data tunnels based on one or more of said bounding operator and a given set of one or more operands.

252. A data storage and/or retrieval system, comprising:

providing storage media comprising a plurality of characteristic data tunnels, one or more of said plurality of characteristic data tunnels having a plurality of characteristic data cells, in which the plurality of characteristic data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of characteristic data tunnels for each attribute is fixed for a given attribute,

in which each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

in which each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

in which each of the characteristic data cells of the plurality of attribute data tunnels has data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said characteristic data cell possessing a property for a given set of one or more operands, and

accessing, with a storage engine that is in communications coupling with the storage media, one or more of the plurality of characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.

253. A method of data storage and/or retrieval implemented on one or more digital data processing systems, comprising

providing storage media comprising a plurality of characteristic data tunnels, one or more of said plurality of characteristic data tunnels having a plurality of characteristic data cells, in which the plurality of characteristic data tunnels include a plurality of entity type data tunnels for each of a plurality of entity types and a plurality of attribute data tunnels for each of a plurality of attributes, in which a number of characteristic data tunnels for each attribute is fixed for a given attribute,

in which each of the characteristic data cells contain data associated with a respective instance of an attribute for a respective and distinct instance of an entity type,

in which each respective instance of an attribute has one respective characteristic data cell in all respective characteristic data tunnels,

- in which each of the characteristic data cells of the plurality of attribute data tunnels has data for which a respective possessive operator evaluates to a boolean result which indicates either the likely possibility or the impossibility of the attribute instance corresponding to said characteristic data cell possessing a property for a given set of one or more operands, and
- 5 accessing, with a storage engine that is in communications coupling with the storage media, one or more of the plurality of characteristic data tunnels based on one or more of said possessive operator and a given set of one or more operands.