Claims

[Claim 1]

A method for representing objects of a network in a Graphical User Interface, GUI, with a graph clustering comprising:

- retrieving a base graph comprising all of said objects of said network as respective nodes and links between said nodes, wherein to each of said nodes is assigned a predefined node mass;
- grouping two or more of said nodes in one or more clusters, by a computerized data processing unit, wherein each of said clusters comprises at least two of said nodes, said clusters comprising child clusters and child nodes;
- initializing said clusters, by said computerized data processing unit, by calculating a cluster mass and a cluster radius of each of said clusters;
- assessing said clusters, by said computerized data processing unit, defining a visualization graph which represents said base graph as seen from a predefined distance value; and
- positioning said visualization graph in said GUI by said computerized data processing unit;

wherein said cluster mass of each of said clusters is calculated as sum of the node masses of all of said nodes arranged inside said cluster and of the child cluster masses of all of the child clusters arranged inside of said cluster,

wherein said cluster radius of each of said cluster is calculated as product of said cluster mass with a predefined radius constant;

wherein said assessing comprises:

- creating, by said computerized data processing unit, a visualization graph that is initially empty;
- calculating, by said computerized data processing unit, for each of said clusters the distance ratio as ratio between said cluster radius and said predefined distance value;
- for each of said clusters, comparing said distance ratio, by said computerized data processing unit, with regard to a predefined distance ratio threshold;

- for each of said clusters, compressing said cluster, by said computerized data processing unit, when the respective distance ratio is higher than said predefined distance ratio threshold, adding in said visualization graph a single compressed cluster node for all child nodes and all child clusters arranged inside said cluster to be compressed;
- for each of said clusters, expanding said cluster, by said computerized data processing unit, when the respective distance ratio is lower than said predefined distance ratio threshold, adding in said visualization graph a plurality of nodes for all child nodes and all child clusters arranged inside said cluster to be expanded;
- adding, by said computerized data processing unit, in the visualization graph a link between two nodes if the same link between the same two nodes is present in the base graph;
- adding, by said computerized data processing unit, in said visualization graph a link between a first cluster and a first node outside said first cluster if a link was present between a respective node inside said first cluster and said first node outside said first cluster in said base graph, wherein every time a link needs to be added between the same of said first cluster and of said first node outside said cluster a count of a link strength is increased of an integer unit; and
- adding, by said computerized data processing unit, in said visualization graph a link between two of said clusters if a link was present between a node inside one of said clusters and a node inside the other of said clusters in said base graph, wherein every time a link needs to be added between the same of two of said clusters a count of a link strength is increased of an integer unit.

[Claim 2]

The method for representing objects of a network in a GUI with a graph clustering according to claim 1, wherein said assessing and said positioning are iterated when said predefined distance value is changed.

[Claim 3]

The method for representing objects of a network in a GUI with a graph clustering according to claim 1 or 2, wherein in said assessing said clusters are compressed if they are outside a predefined visualization window as a portion of the two-dimensional space in which said visualization graph is visualized in said GUI.

[Claim 4]
The method for representing objects of a network in a GUI with a graph clustering according to any one of claims 1 to 3, wherein said positioning of said visualization graph comprises:

- assigning initial position to all of said nodes and of said cluster nodes;
- computing forces acting on each of said nodes and cluster nodes;
- defining new position for said nodes and cluster nodes by means of a velocity verlet algorithm;
- storing said new positions;
- iterating said computing, said defining and said storing until said nodes and said cluster nodes positions become stable.

[Claim 5]
The method for representing objects of a network in a GUI with a graph clustering according to claim 4, wherein said assigning initial position consists of assigning to all of said nodes and of said cluster nodes inside an expanded of said clusters coordinates of the cluster node position if said cluster has never been expanded before.

[Claim 6]
The method for representing objects of a network in a GUI with a graph clustering according to claim 4 or 5, wherein said assigning initial position consists of assigning to all of said nodes and of said cluster nodes inside an expanded of said clusters the coordinates of the relative positions with respect to a cluster center position if the cluster has already been expanded.

[Claim 7]

The method for representing objects of a network in a GUI with a graph clustering according to claim 6, wherein said storing comprises memorizing said cluster center position calculated as:

$$xc = \frac{\sum_{i=0}^{n} m_i * x_i}{\sum_{i=0}^{n} m_i}; \quad yc = \frac{\sum_{i=0}^{n} m_i * y_i}{\sum_{i=0}^{n} m_i}$$

wherein:

- xc is the coordinate of cluster center along an x axis;
- yc is the coordinate of cluster center along an y axis;
- m_i is the mass of the ith cluster element inside the cluster;
- x_i is the coordinate of the ith cluster element along the x axis; and
- y_i is the coordinate of the ith cluster element along the y axis.
- n is the number of elements inside the cluster

[Claim 8]

The method for representing objects of a network in a GUI with a graph clustering according to claim 7, wherein said storing comprises memorizing said relative positions calculated as:

$$xr_i = x_i - xc \qquad yr_i = y_i - yc$$

wherein:

- xr_i is the coordinate of the ith cluster element relative to the coordinate of the cluster center along the x axis;
- yr_i is the coordinate of the ith cluster element relative to the coordinate of the cluster center along the y axis;
- xc is the coordinate of cluster center along the x axis;
- yc is the coordinate of cluster center along the y axis;
- x_i is the coordinate of the ith cluster element along the x axis; and
- y_i is the coordinate of the ith cluster element along the y axis.

[Claim 9]

The method for representing objects of a network in a GUI with a graph clustering according to any one of claims 4 to 8, wherein said computing the forces acting on

each of said nodes and cluster nodes comprises computing link forces of said link as:

$$Flx_{b-a} = K * S * (x_b - x_a); Fly_{b-a} = K * S * (y_b - y_a)$$

and

$$Flx_{a-b} = K * S * (x_a - x_b); Fly_{a-b} = K * S * (y_a - y_b)$$

respectively for said two nodes or cluster nodes "a" and "b" that form said link, wherein:

- K is a predefined elastic constant;
- S is said link strength for each of said link;
- x_a, y_a are coordinates of the "a" node;
- x_b, y_b are coordinates of the "b" node;
- Flx_{b-a} is the x component of the force that node "b" exerts on node "a";
- Fly_{b-a} is the y component of the force that node "b" exerts on node "a";
- Flx_{a-b} is the x component of the force that node "a" exerts on node "b";
- Fly_{a-b} is the y component of the force that node "a" exerts on node "b".

[Claim 10]

The method for representing objects of a network in a GUI with a graph clustering according to any one of claims 4 to 9, wherein said computing the forces acting on each of said nodes and cluster nodes comprises computing gravitational forces between each couple of said nodes and/or cluster nodes identifying the source and the receiver as:

$$Fx = G * Ms * Mr * (xs - xr) / d^3; Fy = G * Ms * Mr * (ys - yr) / d^3$$

wherein:

- Ms is the mass of said source;
- Mr is the mass of said receiver;
- xs, ys are the coordinates of said source;
- xr, yr are the coordinates of said receiver;
- d is the distance between said source and said receiver positions;
- G is a predefined gravitational constant;
- Fx is the x component of the force that the source exerts on the receiver;
- Fy is the y component of the force that the source exerts on the receiver.

[Claim 11]

The method for representing objects of a network in a GUI with a graph clustering according to any one of claims 4 to 8, wherein said computing the forces acting on each of said nodes and cluster nodes comprises computing damping force for each of said nodes and/or cluster nodes as:

$$Fdx = D * Vx; Fdy = D * Vy$$

wherein:

- Vx is the velocity of the node or cluster node along said x axis;
- Vy is the velocity of the node or cluster node along said y axis;
- D is a predefined damping constant;
- Fdx is the x component of the damping force acting on node or cluster node;
- Fdy is the y component of the damping force acting on node or cluster node.

[Claim 12]

The method for representing objects of a network in a GUI with a graph clustering according to any one of claims 4 to 8, wherein said computing the forces acting on each of said nodes and cluster nodes comprises computing central force for each of said nodes and/or cluster nodes as:

$$Fcx = C * x + \sum_{i=0}^{N} C * level_i * (x - xc_i)$$

$$Fcy = C * y + \sum_{i=0}^{N} C * level_i * (y - yc_i)$$

wherein:

- C is a predefined constant;
- N is the number of clusters at which the node or cluster node recursively belongs;
- $Level_i$ is the level of the ith cluster at which the node or cluster node belongs;
- xc_i is the center coordinate along the x axis i^{th} cluster at which the node or cluster node belongs;

- yc_i is the center coordinate along the y axis of the ith cluster at which the node or cluster node belong;
- x is the coordinate of the node or cluster node along the x axis;
- y is the coordinate of the node or cluster node along the y axis;
- Fcx: is the x component of the central force acting on node or cluster node; and
- Fcy is the y component of the central force acting on node or cluster node.