GR 96 P 3452

Description

Updating process

The present invention relates to an updating process for coupling an additional automation system to an overall automation system which has a basic automation system and controls a technical process without interruption. The automation systems each have access to their own main storage area and can exchange data with one another and with the technical process via communication means.

Redundant automation systems of this type are very widespread. In most cases, the automation systems have single or dual redundancy, that is to say two to three automation systems are used to control one and the same technical process or the technical plant. In the case of such a configuration it may occur that one of the automation systems, referred to below as the additional automation system, fails, and the technical plant is managed by the remaining automation system, the basic automation system, or the remaining automation systems.

Updating when coupling an additional automation system to an overall automation system which is formed by at least one automation system is therefore necessary, for example, when in the course of maintenance work one of the automation systems has been stopped temporarily and, following the completion of the maintenance work, is put into operation once more. When coupling the temporarily stopped automation system, it is primarily relevant for the additional automation system which is to be coupled to take over the database from the basic automation system. This operation is referred to as updating.

The subject of the updating process is thus the transmission of the content of the main storage area of a basic automation system to an additional automation system. EP-A-0 636 956 describes an updating process in which, in the basic automation system, the data configurations of non-time-critical states are predefined, as are the associated time durations during which the reaction to state changes in the technical process is not time-critical. If the duration of the non-time-critical state exceeds the time which is necessary for updating, updating is initiated.

If no adequately non-time-critical state exists, the updating according to the process described in EP-A-0 636 956 is carried out within so-called time slices, which are inserted cyclically into the execution of the program. In this case, the actual updating is carried out in each case by reading out section by section from the main storage area of the basic automation system and writing into the main storage area of the additional automation system.

The reading out of data section by section is also time-consuming. In particular for the case in which a time-critical process is controlled by the basic automation system whose data have to be read out, it is necessary to take into account that the controlling basic automation system cannot monitor the process during the reading out and therefore possibly cannot react in good time to state changes in the process. Such short-term "monitoring gaps" in the control of the technical process are often also not tolerable.

The object of the invention is therefore to specify an updating process for coupling an additional automation system to an overall automation system which has a basic automation system and controls a technical process without interruption, it being possible to carry out the updating process without impairing the control of the technical process.

The object is achieved by means of an updating process which is characterized by the features of patent claim 1. Because of the boundary conditions prescribed by the technical process to be controlled, it is not possible to transmit the content of the main storage area of the basic automation system in one go into the additional automation system to be coupled in. The updating is therefore subdivided into two passes.

In a first pass, the content of the main storage area of the basic automation system is transferred by gradually reading it out of the main storage area of the basic automation system and writing it into the main storage area of the additional automation system. The scope of the data in each case read out and written in in one step is determined by the time interval needed for this operation and the maximum tolerable latency phase of the basic automation system in relation to the technical process to be controlled.

If, during the reading out section by section of data from the main storage area of the basic automation system, the same data are written into an intermediate storage area, it is then advantageously possible for the basic automation system to take up the control of the technical process again while the data are being transmitted from the intermediate storage area to the additional automation system. The time during which the basic automation system cannot monitor the technical process is thus shortened by using the intermediate storage area.

The higher the capability of the communication means via which the data are transmitted from the main storage area of the basic automation system into the intermediate storage area, the shorter is the time interval in which the basic automation system cannot monitor the technical process.

A similarly positive influence is achieved by using a high capacity store which is optimum for the application - for example a static RAM or a static RAM as a dual-port RAM - for the intermediate storage area.

After a specific number of the above described reading and writing operations, a transmission of the "basic database" of the basic automation system to the additional automation system has been realized. During this time, however, the data in the main storage area of the basic automation system are subjected to continuous change on account of the uninterrupted control of the technical process, since, for example, timer and counter values and the output signals are changed. Before the updating can be viewed as having been completed, it is also necessary for the equality of these data to be ensured.

The changes which have occurred in the meantime in the basic automation system consequently have to be transmitted in at least one further, subsequent updating pass.

To this end, when writing new and/or changed data into the main storage area of the basic automation system, the same data, together with an item of position information, are also written into the intermediate storage area as well. The content of the intermediate storage area is transmitted to the additional automation system and the data transmitted are written into the main storage area of the additional automation system, whilst evaluating the position information.

In this case, the position information contains data about the position of the changed data in the main storage area of the basic automation system and, moreover, at least information about the quantity of data as well. These items of position information are evaluated when writing into the main storage area of the additional automation system, so that

the data transmitted occupy the same position in the main storage area of the additional automation system as the original data occupy in the main storage area of the basic automation system.

These items of position information are only absolutely necessary during the transmission of new and/or changed values during the at least one further updating pass. In the case of reading data section by section out of the main storage area of the basic automation system and writing these data into the intermediate storage area, the items of position information are not necessary, under the assumption that it is established that the data read out in the intermediate storage area always occupy the same area, and that the area occupied in this way in the intermediate storage area is transmitted to the additional automation system before said intermediate storage area is overwritten during the renewed reading out section by section of data from the main storage area of the basic automation system. In the case of such a procedure, the items of position information are, so to speak, present implicitly. The updating process makes a note of the number of sections read out of the main storage area of the basic automation system and in each case reads the next section using this information. Furthermore, the additional automation system notes the number of sections already written when data are being written into its main storage area, so that in each case the next successive section is updated.

Further advantages and details emerge from the following description of an exemplary embodiment, with reference to the drawing and in conjunction with the further subclaims.

In the drawing:

FIG 1 shows a block diagram of an automation system.

According to FIG 1, a technical process TP - illustrated only schematically - is controlled by an overall automation system AGS. The overall automation system AGS has at least one basic automation system BAS and at least one additional automation system ZAS. The basic automation system BAS is referred to in brief below as the basic system BAS, the additional automation system ZAS is referred to as the additional system ZAS.

In order to control the technical process TP, the automation systems BAS, ZAS have a processor P, which, in order to control the technical process TP, executes a program which is stored in the main memory area HSB. Also stored in the main storage area HSB are at least process data which, for example, represent the current state of the controlled technical process. In addition, the automation systems BAS, ZAS have communication means KM for communicating the technical process TP and for communicating with other automation systems BAS, ZAS of the overall automation system AGS. The basic system BAS and additional system ZAS are essentially of identical construction.

In the present case it is assumed that the basic system BAS exclusively controls the technical process TP, and that the additional system ZAS is intended to be coupled to the basic system BAS in order to take over the control of the technical process TP immediately in the event of any failure of the basic system BAS. For this purpose, not only must the program in the main memory area HSB of the basic system BAS be identical to the program in the main memory area HSB of the additional system ZAS, but it is also necessary for the process data which are stored in the main storage areas HSB of the automation systems BAS, ZAS to agree.

During the updating, the additional system ZAS must of course neither execute the program nor make write peripheral accesses. On the other hand, the concomitant execution of read peripheral

accesses is even advantageous, since by this means the additional system ZAS is implicitly updated.

The content of the main storage area HSB of the basic system BAS is transmitted to the additional system ZAS by reading out section by section and writing it into the main storage area HSB of the additional system ZAS. In the process, when data are being read out section by section from the main storage area HSB of the basic system BAS, the same data are written into an intermediate storage area ZSB. When data are being written, in particular when new and/or changed data are being written, into the main storage area HSB of the basic system BAS, the same data, together with an item of position information, are also written into the intermediate storage area ZSB as well. The content of the intermediate storage area ZSB is transmitted into the additional system ZAS. In this case, the transmission is carried out either by means of actively reading the additional system ZAS or by means of active writing initiated by the instance BAS, ZAS monitoring the intermediate storage area ZSB, the data transmitted from the intermediate storage area ZSB to the additional system ZAS being written into the main storage area HSB of the additional system ZAS. For the case in which the data transmitted from the intermediate storage area ZSB to the additional system ZAS are data with an associated item of position information, these data are evaluated in order to write into the main storage area HSB of the additional system ZAS.

In an advantageous refinement of the updating process, the data which are written into the intermediate storage area ZSB when they are being read out section by section from the main storage area HSB of the basic system BAS are also assigned items of position information. In this way, the transmission of data from the main storage area HSB of the basic system BAS into the intermediate storage area ZSB can be carried out completely decoupled from the transmission of the data from the intermediate

storage area ZSB into the main storage area HSB of the additional system ZAS.

In the case of the transmission of data from the main storage area HSB of the basic system BAS into the intermediate storage area ZSB, data are written into the intermediate storage area ZSB at predetermined times. This makes it possible for the writing of data to take place in each case at those times which are particularly suitable for the transmission of the data, so that the monitoring of the technical process TP to be controlled is impaired as little as possible. These particularly suitable times may be, for example, equidistant times or times which result from a special state - an area/section marked explicitly as uninterruptible, the failure of critical operations within a specific area/section, etc - of the program that is executed in order to control the technical process TP.

The updating takes place particularly rapidly and reliably if those data which, when data are being written into the main storage area HSB of the basic system BAS are also written into the intermediate storage area ZSB as well, are in each case immediately transmitted to the additional system ZAS. In the case of this immediate transmission, too, the decoupling of the transmission operations from the main storage area HSB of the basic system BAS into the intermediate storage area ZSB, and from the intermediate storage area ZSB into the main storage area HSB of the additional system ZAS, is maintained.

Because of the uninterrupted control of the technical process TP by the basic system BAS, the database of the basic system BAS is subjected to continuous change. These changes can quite feasibly also occur in areas which have already been transmitted to the additional system ZAS by being read out and written in section by section. For this reason, for the transmission of new

and/or changed data, an updating process which is particularly oriented to this has to be used. For this purpose, the main storage areas HSB of the basic and additional systems BAS, ZAS, and the intermediate storage area ZSB, are subdivided into segments.

When data are being written into the main storage area HSB of the basic system BAS, the content is read out from that segment to which write access has been made. The content of the entire segment, together with an item of position information, is then written into the intermediate storage area ZSB. The position information again contains, as before, data about the position in the main storage area HSB of the basic system BAS and, moreover, additionally at least information about the quantity of data, that is to say in this case information about the size of the segment.

The content of the entire segment is transmitted from the intermediate storage area ZSB to the additional system ZAS and written into the main storage area HSB of the additional system ZAS, whilst evaluating the position information. In this way, it is possible even for the changes which result during the section-by-section updating to be transmitted rapidly and reliably to the additional system ZAS. For the case in which new and/or changed data result in one and the same segment of the main storage area HSB of the basic system BAS, all the changed data from this segment can be transmitted into the intermediate storage area ZSB in a single transmission operation. This ensures that it is not each changed data item, for example a single byte, that is transmitted singly, but that instead, for example, a complete data structure, for which space is found completely in this segment, can be transmitted.

In order to be able to monitor the changes in the main storage area HSB of the basic system BAS which result during the updating, each segment of the main storage area,

at least of the basic system BAS, is assigned an item of status information. At the start of the updating process, each item of status information is set to a value which indicates that the data from the relevant segment have until now not been transmitted to the additional system ZAS. As soon as the data from a segment have been transmitted to the additional system ZAS, the item of status information of the relevant segment is set to a value which indicates that the data from the relevant segment have been transmitted to the additional system ZAS. If new and/or changed data are written into a segment, the item of status information of the relevant segment is set to a value which indicates that the data of the relevant segment have not yet been transmitted to the additional system ZAS. The status information is evaluated, so that only those data are transmitted to the additional system ZAS whose item of status information indicates that the data of the relevant segment have not yet been transmitted to the additional system ZAS. This therefore makes it possible, in the case of new and/or changed data in the main storage area HSB of the basic system BAS, to transmit the changes selectively.

In a first updating pass, first the data from all the segments of the main storage area HSB of the basic system BAS are then transmitted in a specific sequence to the additional system ZAS. In at least one further updating pass data are then transmitted to the additional system ZAS in each case only from those segments of the main storage area HSB of the basic system BAS whose item of status information indicates that the data from the relevant segment have until now not been transmitted to the additional system ZAS.

In order to control the technical process TP, the basic system BAS executes a control program stored in the main storage area HSB. As is generally usual in the control of technical processes TP, this program is subdivided into individual tasks, each of which is assigned a specific priority. Tasks with which

important and/or time-critical functions have to be monitored receive a high priority, other tasks, whose execution is of lower significance for the control of the technical process TP, such as, for example, the indication of the time of day, receive a low priority. If the execution of specific tasks is deferred from time to time, the time which was previously needed in order to execute these tasks is available for other tasks, for example the updating.

Therefore, in an advantageous refinement, the updating process can be carried out particularly rapidly and efficiently if, after the first updating pass, tasks with a priority below a first priority limit are deferred and if, after the updating process has been completed, tasks with any priority are executed again. After the first updating pass, the basic database of the basic system BAS is transmitted to the additional system ZAS by reading it out section by section from the main storage area of the basic system BAS and writing it into the main storage area HSB of the additional system ZAS. In the course of carrying out the updating process, it is therefore necessary to transmit only the changes which have resulted during this first updating pass. If tasks with a priority below a first priority limit are now deferred, then the time which was previously necessary for executing the tasks with the priority below the first priority limit is also available as well for the transmission of the changes.

Consequently, therefore, very many changed segments can now be transmitted in a single further updating pass. The updating is always completed very rapidly if, in each individual updating pass, the number of segments transmitted is less than the number of changed segments to be added. In order to be able to ensure this reliably in each case, it is possible for the priority limit to be predefinable, so that, for example, it is also possible for the final user to define the first priority limit.

The updating process is completed still more rapidly if, after each further updating pass and/or after a fixed number of further updating passes, tasks with a priority below a next higher priority limit are deferred. Therefore, during further updating passes, the time which is available for updating increases, so that an increasing number of segments can be transmitted. The result of the progressive deferment of tasks is also, finally, only a few new and/or changed data still in the main storage area HSB of the basic system BAS, so that not only is there an increase in the number of segments transmitted, but there is also a decrease in the number of segments to be transmitted on account of changes which have occurred in the meantime.

The updating counts as having been carried out when both the first updating pass, in which first the data from all the segments of the main storage area HSB of the basic system BAS are transmitted in a specific sequence to the additional system ZAS, and the at least one further updating pass, in which data are then transmitted to the additional system ZAS only from those segments of the main storage area HSB of the basic system BAS whose item of status information indicates that the data from the relevant segment still have to be transmitted to the additional system ZAS, have been completed.

For its part, the at least one further updating pass has been completed when all the status information from the segments of the main storage area HSB of the basic system BAS indicate that the data from the relevant segment have already been transmitted to the additional system ZAS.

Once the updating counts as having been carried out, in some cases it is additionally possible - in order to increase security - for a test variable relating to the data to be updated or which have been updated to be ascertained in both automation systems BAS, ZAS. The test

variable may be, for example, a checksum or a signature. The test variables ascertained are exchanged via the communication means KM and compared with one another. If the test variables are identical, the updating counts as having been completed without error, otherwise the updating process is repeated completely or partially. In the event of an error, in order to permit the partial repetition of the updating as well, the test variable may be constructed in such a way that it is possible to ascertain, by means of suitable interpretation, for which data the updating process is to be partially repeated.

The updating may be realized by an overall automation system AGS which has an intermediate storage area ZSB and carries out the updating process described. In an advantageous refinement - deviating from the illustration in FIG 1 - one of the automation systems BAS, ZAS of such an overall automation system AS has the intermediate storage area ZSB. The automation system BAS, ZAS may be either the basic automation system BAS or the additional automation system ZAS.

Patent Claims

1. An updating process for coupling an additional automation system (ZAS) to an overall automation system (AGS) which has a basic automation system (BAS) and controls a technical process (TP) without interruption, the automation systems (BAS, ZAS) each having access to their own main storage area (HSB) and exchanging data via communication means (KM), the content of the main storage area (HSB) of the basic automation system (BAS) being subjected to continuous changes on account of the uninterrupted control of the technical process (TP) and being transmitted to the additional automation system (ZAS) by being read out section by section and written into the main storage area (HSB) of the latter system, characterized

- in that when the data are being read out section by section from the main storage area (HSB) of the basic automation system (BAS), the same data are written into an intermediate storage area (ZSB),
- in that when the data are being written into the main storage area (HSB) of the basic automation system (BAS), the same data, together with an item of position information, are also written into the intermediate storage area (ZSB) as well,
- in that the content of the intermediate storage area (ZSB) is transmitted to the additional automation system (ZAS) and
- in that the data transmitted from the intermediate storage area (ZSB) to the additional automation system (ZAS) are written into the main storage area (HSB) of the additional automation system (ZAS), if necessary whilst evaluating the position information.

2. The updating process as claimed in claim 1, characterized in that when the data are being read out section by section from the main storage area (HSB) of the basic automation system (BAS), the same data, together with an

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item of position information, are written into the intermediate storage area (ZSB).

3. The updating process as claimed in claim 1 or 2, characterized in that data are written into the intermediate storage area (ZSB) at predetermined times in each case.

4. The updating process as claimed in claim 1, 2 or 3, characterized in that those data which, when data are being written into the main storage area (HSB) of the basic automation system (BAS), are also written into the intermediate storage area (ZSB) as well, are in each case transmitted immediately to the additional automation system (ZAS).

5. The updating process as claimed in one of claims 1 to 4, characterized

- in that the main storage areas (HSB) are subdivided into segments,
- in that when data are being written into the main storage area (HSB) of the basic automation system (BAS), the content is read out from that segment to which write access has been made,
- in that the content of the entire segment is transmitted to the additional automation system (ZAS) and written into its main storage area (HSB).

6. The updating process as claimed in one of claims 1 to 4, characterized

- in that the main storage areas (HSB) and the intermediate storage area (ZSB) are subdivided into segments,
- in that when data are being written into the main storage area (HSB) of the basic automation system (BAS), the content is read out from that segment to which write access has been made,

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- in that the content of the entire segment, together with an item of position information, is then written into the intermediate storage area (ZSB) and
- in that the content of the entire segment is transmitted from the intermediate storage area (ZSB) to the additional automation system (ZAS) and is written into its main storage area (HSB), whilst evaluating the position information.

7. The updating process as claimed in claim 5 or 6, characterized

- in that each segment of the main storage area (HSB), at least of the basic automation system (BAS), is assigned an item of status information,
- in that at the start of the updating process each item of status information is set to a value which indicates that the data from the relevant segment have until now not been transmitted to the additional automation system (ZAS),
- in that the item of status information of a segment is set to a value which indicates that the data from the relevant segment have been transmitted to the additional automation system (ZAS) when the data from the relevant segment are transmitted to the additional automation system (ZAS),
- in that the item of status information of a segment is set to a value which indicates that the data from the relevant segment still have to be transmitted to the additional automation system (ZAS) if new or changed data are written into the segment,
- in that the items of status information are evaluated, so that data are transmitted to the additional automation system (ZAS) only from those segments whose item of status information indicates that the data from the relevant segment still has to be transmitted to the additional automation system (ZAS).

8. The updating process as claimed in claim 7, characterized

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- in that, in a first updating pass, first the data from all the segments of the main storage area (HSB) of the basic automation system (BAS) are transmitted in a specific sequence to the additional automation system (ZAS),
- in that, in at least one further updating pass, data are then transmitted to the additional automation system (ZAS) in each case only from those segments of the main storage area (HSB) of the basic automation system (BAS) whose item of status information indicates that the data from the relevant segment until now still have to be transmitted to the additional automation system (ZAS).

9. The updating process as claimed in claim 8, characterized

- in that the basic automation system (BAS), in order to control the technical process (TP), executes tasks which are each assigned a specific priority,
- in that, after the first updating pass, tasks with a priority below a first priority limit are deferred, and
- in that, after the updating process has been completed, tasks with any priority are executed again.

10. The updating process as claimed in claim 9, characterized in that, after each further updating pass, tasks with a priority below a next higher priority limit are deferred.

11. An overall automation system for the uninterrupted control of a technical process, which has a basic automation system (BAS),

- it being possible to couple an additional automation system (ZAS) to the overall automation system (AGS),
- both automation systems (BAS, ZAS) having at least
  -- a main storage area (HSB), in which at least data and/or machine instructions are stored,

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--a processor (P) for controlling the technical process (TP) by executing the machine instructions,

--communication means (KM) for communicating with the technical process (TP) and communication means (KM) for communicating with other automation systems (BAS, ZAS) of the overall automation system (AGS) and

--a bus, which connects at least the communication means (KM), processor (P) and main storage area (HSB) to one another,

- the content of the main storage area (HSB) of the basic automation system (BAS)

-- being subjected to continuous changes on account of the uninterrupted control of the technical process (TP) and

-- it being possible for this content to be transmitted to the additional automation system (ZAS) by reading it out section by section and writing it into the main storage area (HSB) of the latter system (ZAS),

characterized

- in that the overall automation system (AGS) has an intermediate storage area (ZSB),
- in that when the data are being read out section by section from the main storage area (HSB) of the basic automation system (BAS), the same data can be written into the intermediate storage area (ZSB),
- in that when data are being written into the main storage area (HSB) of the basic automation system (BAS), the same data, together with an item of position information, can also be written into the intermediate storage area (ZSB) as well,
- in that the content of the intermediate storage area (ZSB) can be transmitted to the additional automation system (ZAS) and
- in that the data that can be read out by the first automation system (ZAS) from the intermediate storage area (ZSB) can be written into the main storage area (HSB) of the additional automation system (ZAS), if necessary whilst evaluating the position information.

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12. The automation system as claimed in claim 11, characterized in that when the data are being read out section by section from the main storage area (HSB) of the basic automation system (BAS), the same data, together with an item of position information, can be written into the intermediate storage area (ZSB).

13. The automation system as claimed in claim 11 or 12, characterized

- in that the main storage areas (HSB) of the automation systems (ZAS, BAS), and the intermediate storage area (ZSB), are subdivided into segments,
- in that when data are being written into the main storage area (HSB) of the basic automation system (BAS), it is possible to read out the content of that segment to which write access has been made,
- in that the content of the entire segment, together with an item of position information, can then be written into the intermediate storage area (ZSB) and
- in that the content of the entire segment can be transmitted from the intermediate storage area (ZSB) to the additional automation system (ZAS) and can be written into its main storage area (HSB), whilst evaluating the position information.

14. The automation system of an overall automation system as claimed in one of claims 11 to 13, characterized in that the automation system (BAS, ZAS) has the intermediate storage area (ZSB).

15. The automation system of an overall automation system as claimed in one of claims 11 to 14, characterized in that each segment of the main storage area (HSB) is assigned an item of status information whose evaluation enables the updating process as claimed in one of claims 7 to 10 to be carried out.