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CONNECTING A GROUP OF INDUSTRIAL TOOLS TO A PLURALITY OF CONTROLLERS USING SHARED SINGLE VIRTUAL IP ADDRESS AND IDENTIFIERS

Abstract

The present disclosure relates to a method of a network device of connecting a group of industrial tools to a plurality of controllers, and a network device performing the method. In an aspect, a method of a network device of connecting a group of industrial tools to a plurality of controllers. The method comprises assigning a single virtual IP address to be shared among the industrial tools in said group, assigning the single virtual IP address to be shared among the plurality of controllers and routing data between the industrial tools and the controllers via the assigned single virtual IP address.

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Background/Summary

TECHNICAL FIELD

[0001] The present disclosure relates to a method of a network device of connecting a group of industrial tools to a plurality of controllers, and a network device performing the method.

BACKGROUND

[0002] Modern industrial tools are typically in wireless communication with remotely located controllers utilized to control the tools, e.g. for sending operational settings to be applied by the tool or instructions to be displayed to an operator via a display of the tool. In another example, the tool being for instance a tightening tool may communicate measured torque values to the controllers for further evaluation.

[0003] In a practical implementation such as at an industrial premise in the form of a factory, a large group of tools may be connected to a great number of controllers. Hence, hundreds of tools may be connected to hundreds of controllers.

[0004] Such a practical implementation requires a great amount of network resources to be assigned. In particular, each tool and each controller must be assigned an Internet Protocol (IP) via which the respective tool and controller may be addressed.

SUMMARY

[0005] One objective is to solve, or at least mitigate, this problem in the art and thus to provide an improved method of a network device of connecting a group of industrial tools to a plurality of controllers.

[0006] This objective is attained in a first aspect by a method of a network device (that is, a method performed by a network device) of connecting a group of industrial tools to a plurality of controllers. The method comprises assigning a single virtual IP address to be shared among the industrial tools in said group, assigning the single virtual IP address to be shared among the plurality of controllers and routing data between the industrial tools and the controllers via the assigned single virtual IP address.

[0007] This objective is attained in a second aspect by a network device configured to connect a group of industrial tools to a plurality of controllers, the network device comprising a processing unit and a memory, said memory containing instructions executable by said processing unit, whereby the network device is operative to assign a single virtual IP address to be shared among the industrial tools in said group, assign the single virtual IP address to be shared among the plurality of controllers, and to route data between the industrial tools and the controllers via the assigned single virtual IP address.

[0008] Advantageously, rather than having to assign tens or hundreds of static IP addresses to the tools and the controllers i.e. one specific IP address for each tool and one specific IP address for each controller, a single virtual IP address is assigned for connecting a particular tool to a particular controller which saves network resources in the form IP addresses.

[0009] In an embodiment, the method comprises assigning to each industrial tool in the group a unique identifier being utilized to address an individual industrial tool in the group via the assigned

single virtual IP address.
[0010] In an embodiment, the method comprises assigning to each controller a unique identifier being utilized to address an individual controller among the plurality of controllers via the assigned single virtual IP address.
[0011] In an embodiment, the identifier is included in a data packet to be communicated to a selected individual industrial tool or selected individual controller via the assigned single virtual IP address.
[0012] In an embodiment, the method comprises performing data packet inspection to extract an identifier and determining, based on the extracted identifier, to which individual industrial tool (or controller the data packet is to be routed via the assigned single virtual IP address.
[0013] In an embodiment, the identifier is a serial number of the individual industrial tool or controller.
[0014] In an embodiment, the method comprises storing operational data of each industrial tool.
[0015] In an embodiment, the industrial tools are tightening tools.
[0016] In a third aspect, a computer program is provided comprising computer-executable instructions for causing the network device to perform steps recited in the method of the first aspect when the computer-executable instructions are executed on a processing unit included in the network device.
[0017] In a fourth aspect, a computer program product is provided comprising a computer readable medium, the computer readable medium having the computer program according to the third aspect embodied thereon.
[0018] Generally, all terms used in the claims are to be interpreted according to their ordinary meaning in the technical field, unless explicitly defined otherwise herein. All references to "a/an/the element, apparatus, component, means, step, etc." are to be interpreted openly as referring to at least one instance of the element, apparatus, component, means, step, etc., unless explicitly stated otherwise. The steps of any method disclosed herein do not have to be performed in the exact order disclosed, unless explicitly stated.

Description

BRIEF DESCRIPTION OF THE DRAWINGS
[0019] Aspects and embodiments are now described, by way of example, with reference to the accompanying drawings, in which:
[0020] FIG. **1** illustrates an industrial tool for which tool embodiments may be implemented;
[0021] FIG. **2** illustrates a prior art communication scenario;
[0022] FIG. **3** illustrates a network device according to an embodiment;
[0023] FIG. **4** shows a flowchart illustrating a method according to an embodiment;
[0024] FIG. **5** illustrates a network device routing data from a control to a tool according to an embodiment;
[0025] FIG. **6** shows a flowchart illustrating a method according to another embodiment;
[0026] FIG. **7** shows a flowchart illustrating a method according to a further embodiment; and
[0027] FIG. **8** illustrates a network device according to an embodiment.
DETAILED DESCRIPTION
[0028] The aspects of the present disclosure will now be described more fully hereinafter with reference to the accompanying drawings, in which certain embodiments of the invention are shown.
[0029] These aspects may, however, be embodied in many different forms and should not be construed as limiting; rather, these embodiments are provided by way of example so that this disclosure will be thorough and complete, and to fully convey the scope of all aspects of invention

to those skilled in the art. Like numbers refer to like elements throughout the description.
[0030] FIG. **1** illustrates an industrial tool in the form of a tightening tool **10** configured to apply a torque to a fastener such as a bolt **20**, for which tool embodiments may be implemented.
[0031] The tightening tool **10** may be cordless or electrically powered via a cord and has a main body **11** and a tool head **12**. The tool head **12** has an output shaft **13** with a socket (not shown) configured to be rotatably driven by an electric motor arranged inside the main body **11** to apply the torque to the bolt **20**.
[0032] The tightening tool **10** may be arranged with a display **14** via which an operator of the tool **10** may be presented with information relating to operation of the tool **10**, and an interface **15** via which the operator may input data to the tool **10**.
[0033] The tightening tool **10** may further be arranged with communicating capability in the form of a radio transmitter/receiver **16** for wirelessly transmitting operational data, such as applied torque, to a remotely located controller such as a cloud server **30**. Alternatively, communication between the tool **10** and the controller **30** may be undertaken via a wired connection.
[0034] Thus, the tool **10** may for instance communicate measured torque values to the controller **30** for further evaluation while the controller **30** e.g. may send operational settings to be applied by the tool **10** or instructions to be displayed to the operator via the display **14**.
[0035] Now with reference to FIG. **2**, in a practical implementation such as at an industrial premise in the form of a factory, a large group of tools **10***a*, **10***b*, . . . , **10***n* may be connected to a great number of controllers **30***a*, **30***b*, . . . **30***n*. Hence, hundreds of tools may be connected to hundreds of controllers.
[0036] Such a practical implementation requires a great amount of network resources to be assigned. In particular, each tool and each controller must be assigned an Internet Protocol (IP) via which the respective tool and controller may be addressed.
[0037] To resolve this issue, a network device **40** is proposed being configured to connect the tools **10***a-n* to the controllers **30***a-n* as illustrated in FIG. **3**. Thus, the network device **40** acts as an intermediary device for connecting the tools **10***a-n* to the controllers **30***a-n*.
[0038] Reference is further made to FIG. **4** showing a flowchart illustrating a method of the network device **40** of connecting the group of industrial tools **10***a*-**10***n* to the plurality of controllers **30***a*-**30***n*.
[0039] Hence, in step S**101**, the network device **40** assigns to the group of tools **10***a-b* a single virtual IP address (SVIP) to be shared among the tools **10***a*-**10**.
[0040] Further, the network device **49** assigns in step S**102** the single virtual IP address to the controllers, **30***a-n*, also for sharing among the controllers.
[0041] Thereafter, in step S**103**, any data transmitted between the industrial tools **10***a-c* and the controllers **30***a-c* (in any direction) is routed via the single virtual IP address assigned by the network device **40**.
[0042] Advantageously, rather than having to assign tens or hundreds of static IP addresses to the tools **10***a-n* and the controllers **30***a-n*, i.e. one specific IP address for each tool and one specific IP address for each controller, a single virtual IP address is assigned for connecting a particular tool to a particular controller which saves network resources in the form IP addresses.
[0043] FIGS. **5** and **6** illustrate a further embodiment. Since the tools **10***a*-**10***n* and the controllers **30***a-n* share the single virtual IP address having been assigned, data to be transmitted from a controller to a tool (and vice) versa must somehow be addressed to the individual tool for which the data is intended.
[0044] Thus, the network device **40** assigns in step S**104** to each industrial tool **10***a-n* in the group a unique identifier being utilized to address an individual industrial tool in the group via the assigned single virtual IP address.
[0045] Similarly, for communication to be enabled in the direction from the tools **10***a-n* to the controllers **30***a-n*, the network device **40** assigns in step S**105** to each controller **30***a-n* a unique

identifier being utilized to address an individual controller via the assigned single virtual IP address.

[0046] Assuming for instance that first controller **30***a* wishes to send control data to first tool **10***a*, the first controller will address the first tool using the unique identifier having been assigned to the first tool **10***a*.

[0047] When the network device **40** receives the data from the first controller **30***a* via the assigned single virtual IP address, the network device **40** will determine from the identifier stated by the first controller **30***a* to which tool the data is intended, i.e. the first tool **10***a*, and consequently forward the data to the first tool **10***a* via the assigned single virtual first IP address

[0048] In an example, the network device **40** will setup a mapping table where each unique identifier is mapped to a physical tool/controller.

[0049] An example of tool-identifier mapping is shown below. As is understood, a similar mapping is made for the controllers. [0050] 10001 à First tool **10***a* [0051] 10002 à Second tool **10***b*, and so on.

[0052] In an embodiment, the identifier being utilized is the serial number of the tool (and similarly for the controllers). In the above example, the serial number of the first tool **10***a* is “10001” while the serial number of the second tool **10***b* is “10002”.

[0053] Assuming that the first controller **30***a* is to establish a connection to a tool (or vice versa), e.g. the first tool **10***a*, it transmits a data packet to the assigned single virtual IP address. The data packet could have the appearance of:

TABLE-US-00001 10001 Payload data

[0054] In other words, the data packet transmitted will comprise the identifier of the first tool **10***a*, in this example the serial number of the tool, followed by any payload data to be delivered to the tool, for instance an operational setting to be changed at the tool **10***a* regarding e.g. torque to be applied. In case the transmission is performed in the other direction, i.e. from the first tool **10***a* to the first controller **30***a*. the payload data may include dynamic and static information describing the tool.

[0055] With reference to FIG. **7**, the network device **40** will thus from packet inspection conclude in step **106** that the data packet should be delivered in step S**107** via the assigned single virtual IP address to the first tool **10***a* rather than any other of the group of tools to which the single virtual IP address also is assigned. If the transmission is performed in the other direction, data is delivered to an intended controller in the group of controllers. The network device **40** will thus route the data to the correct tool or controller based on the extracted identifier and a mapping from tool identifier to controller identifier.

[0056] The network device **40** will establish a connection with tool **10***a*, and also a connection with controller **30***a*, forwarding the payload data from tool **10***a* or the controller **30***a* depending on the direction of transmission. Further communication back-and-forth between tool and controller will be routed through the network device **40** on the established connections using the single virtual IP address.

[0057] The network device **40** may for instance use a look-up table stored locally to determine to which individual tool (or controller) the data packet is to be delivered by associating the respective tool (or controller) with an identifier in the look-up table.

[0058] A further advantage of using the single virtual IP address is that no reconfiguration is required should one or more of the tools or controllers move; the single virtual IP address and identifier may still be used.

[0059] Moreover, if e.g. a controller would be disconnected or if a failure would occur at a controller, the tool(s) served by that controller may be swiftly redirected to another controller.

[0060] Further advantageous is that all tools can have the same network configuration, regardless of which controller application the tool is assigned to.

[0061] In yet an embodiment, the network device **40** hosts a database serving as an inventory of all

connected tools, containing data and metrics for each individual tool.
[0062] The steps of the method to be described in the following as performed by the network device **40** are in practice performed by a processing unit **41** embodied in the form of one or more microprocessors arranged to execute a computer program **42** downloaded to a storage medium **43** associated with the microprocessor, such as a Random Access Memory (RAM), a Flash memory or a hard disk drive. The processing unit **41** is arranged to cause the network device **41** to carry out the method according to embodiments when the appropriate computer program **42** comprising computer-executable instructions is downloaded to the storage medium **43** and executed by the processing unit **41**. The storage medium **43** may also be a computer program product comprising the computer program **42**. Alternatively, the computer program **42** may be transferred to the storage medium **43** by means of a suitable computer program product, such as a Digital Versatile Disc (DVD) or a memory stick. As a further alternative, the computer program **42** may be downloaded to the storage medium **43** over a network. The processing unit **41** may alternatively be embodied in the form of a digital signal processor (DSP), an application specific integrated circuit (ASIC), a field-programmable gate array (FPGA), a complex programmable logic device (CPLD), etc. The network device **40** further comprises an interface via which the processing unit **41** wirelessly receives and transmits data.
[0063] The aspects of the present disclosure have mainly been described above with reference to a few embodiments and examples thereof. However, as is readily appreciated by a person skilled in the art, other embodiments than the ones disclosed above are equally possible within the scope of the invention, as defined by the appended patent claims.
[0064] Thus, while various aspects and embodiments have been disclosed herein, other aspects and embodiments will be apparent to those skilled in the art. The various aspects and embodiments disclosed herein are for purposes of illustration and are not intended to be limiting, with the true scope and spirit being indicated by the following claims.

Claims

1. (canceled)
2. (canceled)
3. (canceled)
4. (canceled)
5. (canceled)
6. (canceled)
7. (canceled)
8. (canceled)
9. (canceled)
10. (canceled)
11. (canceled)
12. (canceled)
13. (canceled)
14. (canceled)
15. (canceled)
16. A method of a network device of connecting a group of industrial tools to a plurality of controllers, comprising: assigning a single virtual IP address to be shared among the industrial tools in said group of industrial tools; assigning the single virtual IP address to be shared among the plurality of controllers; routing, through the network device, data between the industrial tools and the controllers via the assigned single virtual IP address; assigning to each industrial tool in the group of industrial tools a unique identifier being utilized to address an individual industrial tool in the group via the assigned single virtual IP address; assigning to each controller a unique identifier

being utilized to address an individual controller among the plurality of controllers via the assigned single virtual IP address, the unique identifier being included in a data packet to be communicated to a selected individual industrial tool or selected individual controller via the assigned single virtual IP address; performing data packet inspection to extract the unique identifier; and determining, based on the extracted unique identifier, to which individual industrial tool or controller the data packet is to be routed through the network device via the assigned single virtual IP address.

17. The method of claim 16, the identifier being a serial number of the individual industrial tool or controller.

18. The method of claim 16, further comprising: storing operational data of each industrial tool.

19. The method of claim 16, wherein the industrial tools are tightening tools.

20. A computer program product stored on a computer readable medium, said computer program product for use in a network device for connecting a group of industrial tools to a plurality of controllers, wherein said computer program product comprising computer instructions to cause one or more processing devices to perform the following operations: assigning a single virtual IP address to be shared among the industrial tools in said group of industrial tools; assigning the single virtual IP address to be shared among the plurality of controllers; routing, through the network device, data between the industrial tools and the controllers via the assigned single virtual IP address; assigning to each industrial tool in the group of industrial tools a unique identifier being utilized to address an individual industrial tool in the group of industrial tools via the assigned single virtual IP address; assigning to each controller a unique identifier being utilized to address an individual controller among the plurality of controllers via the assigned single virtual IP address, the unique identifier being included in a data packet to be communicated to a selected individual industrial tool or selected individual controller via the assigned single virtual IP address; performing data packet inspection to extract the unique identifier; and determining, based on the extracted unique identifier, to which individual industrial tool or controller the data packet is to be routed through the network device via the assigned single virtual IP address.

21. A network device configured to connect a group of industrial tools to a plurality of controllers, the network device comprising a processing unit and a memory, said memory containing instructions executable by said processing unit, whereby the network device is operative to: assign a single virtual IP address to be shared among the industrial tools in said group of industrial tools; assign the single virtual IP address to be shared among the plurality of controllers; route data between the industrial tools and the controllers through the network device via the assigned single virtual IP address; assign to each industrial tool in the group of industrial tools a unique identifier being utilized to address an individual industrial tool in the group via the assigned single virtual IP address; assign to each controller a unique identifier being utilized to address an individual controller among the plurality of controllers via the assigned single virtual IP address, the unique identifier being included in a data packet to be communicated to a selected individual industrial tool or selected individual controller via the assigned single virtual IP address; perform data packet inspection to extract the unique identifier; and determine, based on the extracted unique identifier, to which individual industrial tool or controller the data packet is to be routed through the network device via the assigned single virtual IP address.

22. The network device of claim 21, the identifier being a serial number of the individual industrial tool or controller.

23. The network device of claim 21, further comprising: storing operational data of each industrial tool.

24. The network device of claim 21, wherein the industrial tools are tightening tools.

25. The computer program product of claim 20, the identifier being a serial number of the individual industrial tool or controller.

26. The computer program product of claim 20, wherein said computer program product further

comprising computer instructions to cause one or more processing devices to perform the following operation: storing operational data of each industrial tool.

27. The computer program product of claim 20, wherein the industrial tools are tightening tools.