

IPC-HERMES-9852

Version 1.2

2019 - June

The Global Standard for Machine-to-Machine Communication in SMT Assembly

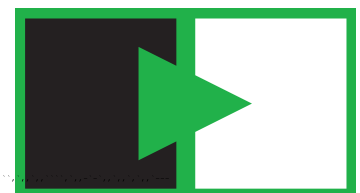
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April 2018

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- Include a feedback system on use and problems for future improvement

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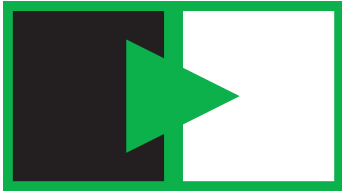
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April 2018

Users of this publication are encouraged to participate in the development of future revisions.

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Acknowledgment

Open standards are the future!

This is particularly true for The Hermes Standard, IPC-HERMES-9852. It is an open standard, and every vendor of assembly equipment for the electronics industry is invited to join.

Although initiated by a small group of people who believed in the power of open standards, it was developed further based on input from many different people from various companies. They have been actively contributing both to the discussions at the joint development web platform and at the regular members' meetings in the final decision-making process.

To bring forward this new standard in such a short amount of time takes both talent and hard work from many individuals in all areas. This included sometimes tedious development groundwork to overcome technical challenges, inspiring thoughts regarding general approaches, the ability to convince others and the industrial community to work jointly towards a common goal, and the determination to bring everything together. Most of all, however, it took commitment and excitement from many people who cannot be individually listed here.

Therefore, the most gratitude and respect shall be extended to all of them collectively. Setting forth from the key motto that was coined at the initial meeting in March 2017, **“You all have started it,”** now let's go on further shaping the future of the electronics industry.

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The Global Standard for Machine-to-Machine Communication in SMT Assembly

1 SCOPE

The aim of this specification is to create a state-of-the-art communication protocol for surface-mount technology (SMT) production lines. Therefore, this new communication protocol has to cope with the following:

- Replace the electrical SMEMA interface as specified in IPC-SMEMA-9851
- Extend the interface to communicate (including):
 - Unique identifiers (IDs) for the handled printed boards
 - Equipment identifiers of the first machine noticing a printed board
 - Barcodes
 - Conveyor speed
 - Product type specific information (including):
 - Product type identifier
 - Length
 - Width
 - Thickness

With respect to version numbers IPC-HERMES-9852 adheres to the rules of Semantic Versioning 2.0.0 (SemVer_2.0.0).

Hints on naming

- Wherever a feature is described by the word “**shall**” it is mandatory.
- The word “machine” is used for any equipment which can be found in a SMT production line (e.g., printers, placement machines, ovens, automatic optical inspections (AOIs), transport modules, shuttles, stackers, etc.).
- The term “printed board” may also refer to carriers transporting printed boards.
- The word “Hermes” is used as abbreviation for “IPC-HERMES-9852”.
- “The Hermes Standard” and IPC-HERMES-9852 are synonyms for the standard specified in this document and might be used interchangeably.

2 TECHNICAL CONCEPT

2.1 Prerequisites This specification is based on the prerequisite, that any application implementing this protocol has to provide connectivity based on Internet Protocol (IP) (IETF_RFC_791) / (IETF_RFC_2460) via Transmission Control Protocol (TCP) (IETF_RFC_793) (International Organization for Standardization / Open System Interconnection (ISO / OSI) model (ISO_7498-1) layer 3) to the adjacent machines and for communication with supervisory systems.

2.2 Board IDs Board individuals are identified by board IDs. These must be globally unique identifiers (GUIDs) according to ITU-T_REC_X.667 (e.g., 123e4567-e89b-12d3-a456-426655440000). They are generated by the first machine in a consecutive row of machines implementing the Hermes protocol. The board ID is passed from machine to machine. If a machine in a line does not implement the Hermes protocol, the board ID is lost and a new one will be generated by the next machine implementing Hermes. This is shown in Figure 1.

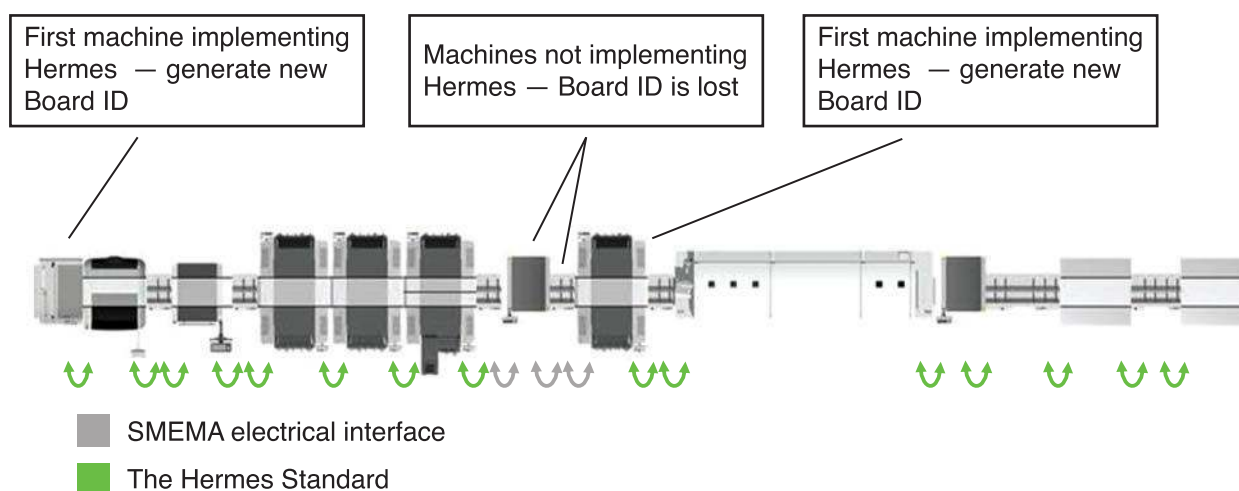


Figure_1 Generation of Board IDs

2.3 Machine-to-Machine Communication (Horizontal Channel)

2.3.1 Topology Any machine in a line offers one TCP server per lane on its downstream side. Further servers per lane might also be necessary (e.g., if reverse transportation is supported). The TCP port number is not specified but can be configured by the user. The recommended port numbers are 50100 plus lane identifier (ID) with lanes being enumerated looking downstream from right to left beginning with 1 (i.e., for the left lane of a dual-lane machine, the upstream machine server accepts connections on port 50102). For every further server, plus 10 is recommended to be added to the port number.

The downstream machine opens one connection for every lane and every transportation interface on its upstream side to the upstream machine(s). So every printed board handover point corresponds to one TCP connection per exchange direction as shown in Figure 2.

Figure 3 explains the applied wording from the point-of-view of a machine.

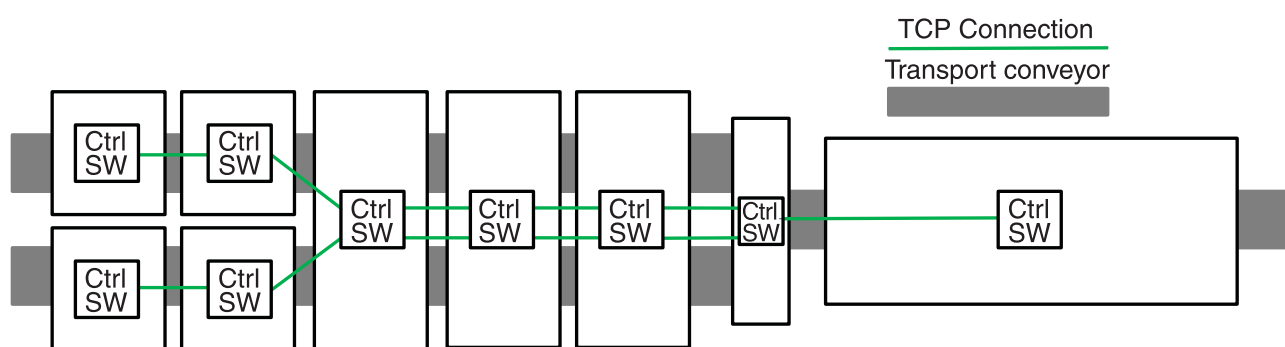


Figure 2 TCP Connections in a Line

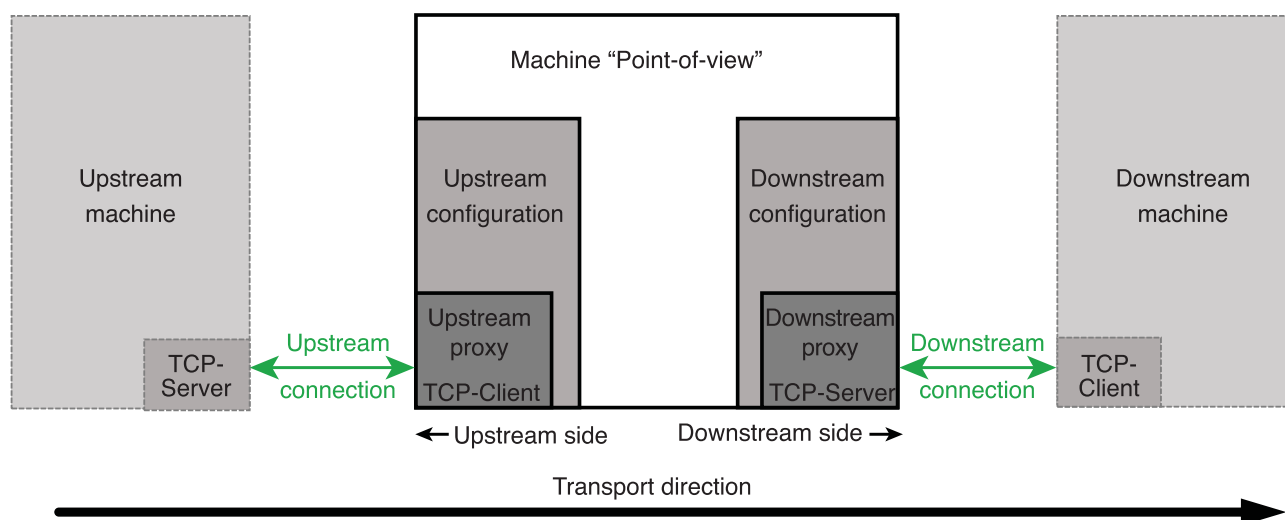


Figure 3 Upstream and Downstream from the Perspective of the Machine

2.3.2 Connecting, Handshake and Detection of Connection Loss After booting, the downstream machine starts cyclic connection attempts to the configured upstream machines. When a connection is established, the downstream machine starts sending a ServiceDescription message, whereupon the upstream machine answers with its own ServiceDescription. This ServiceDescription message contains the lane ID and interface ID (optional) of the sending machine related to this TCP connection. It also contains the implemented version and a list of all optional features and additional features of a higher version which are implemented by the machine. The features of the Hermes specification version 1.0 have to be supported by any implementation. See Figure 4.

If a downstream machine is already connected to the lane and the transportation interface, this connection will be retained. A Notification message **shall** be sent to the new connection before it is closed.

After exchanging the handshake messages, both machines may begin to send BoardAvailable / MachineReady messages (see 2.3.3).

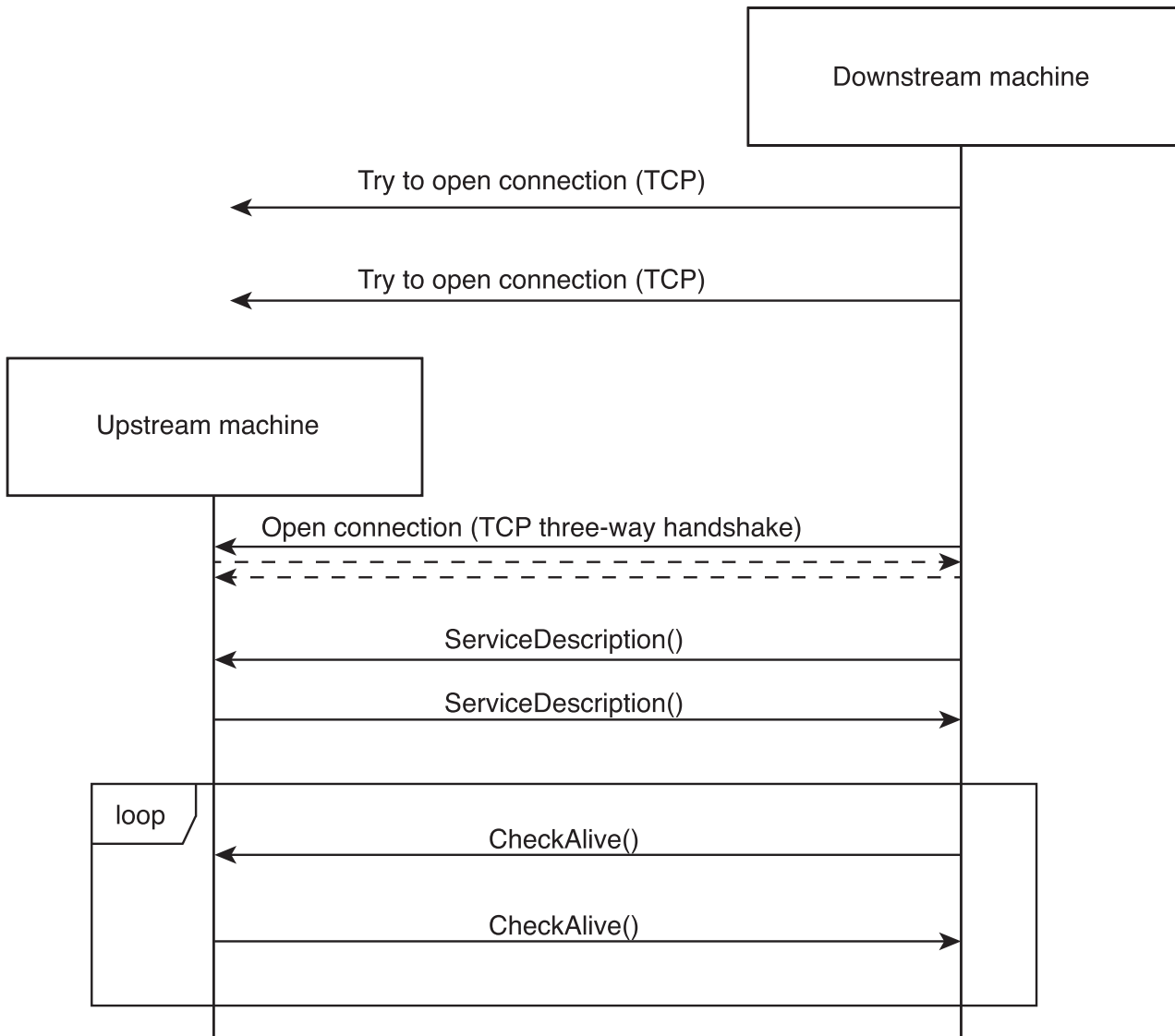


Figure 4 Connection, Handshake and Connection Loss Detection on Horizontal Channel

The connections are kept open all the time. As TCP by itself does not detect connection losses (“half-open connections” caused by, for example, process / computer crash, unplugged network cables, etc.) both sides of a connection have to send cyclic CheckAlive messages. Those messages do not have to be answered by the remote side – the TCP stack will detect a connection loss when trying to send the packet. If the server detects a connection loss, it ends the connection and waits for a new connection by the client. If the client detects a connection loss, it ends the connection and restarts with cyclic connection attempts.

As not all TCP stacks correctly recognize the loss of connection when sending messages, it is possible to extend the implementation of this functionality to an exchange of CheckAlive messages. Machines which have implemented this function have the tag FeatureCheckAliveResponse in the ServiceDescription.

The exchange of CheckAlive messages then works like shown in Figure 5.

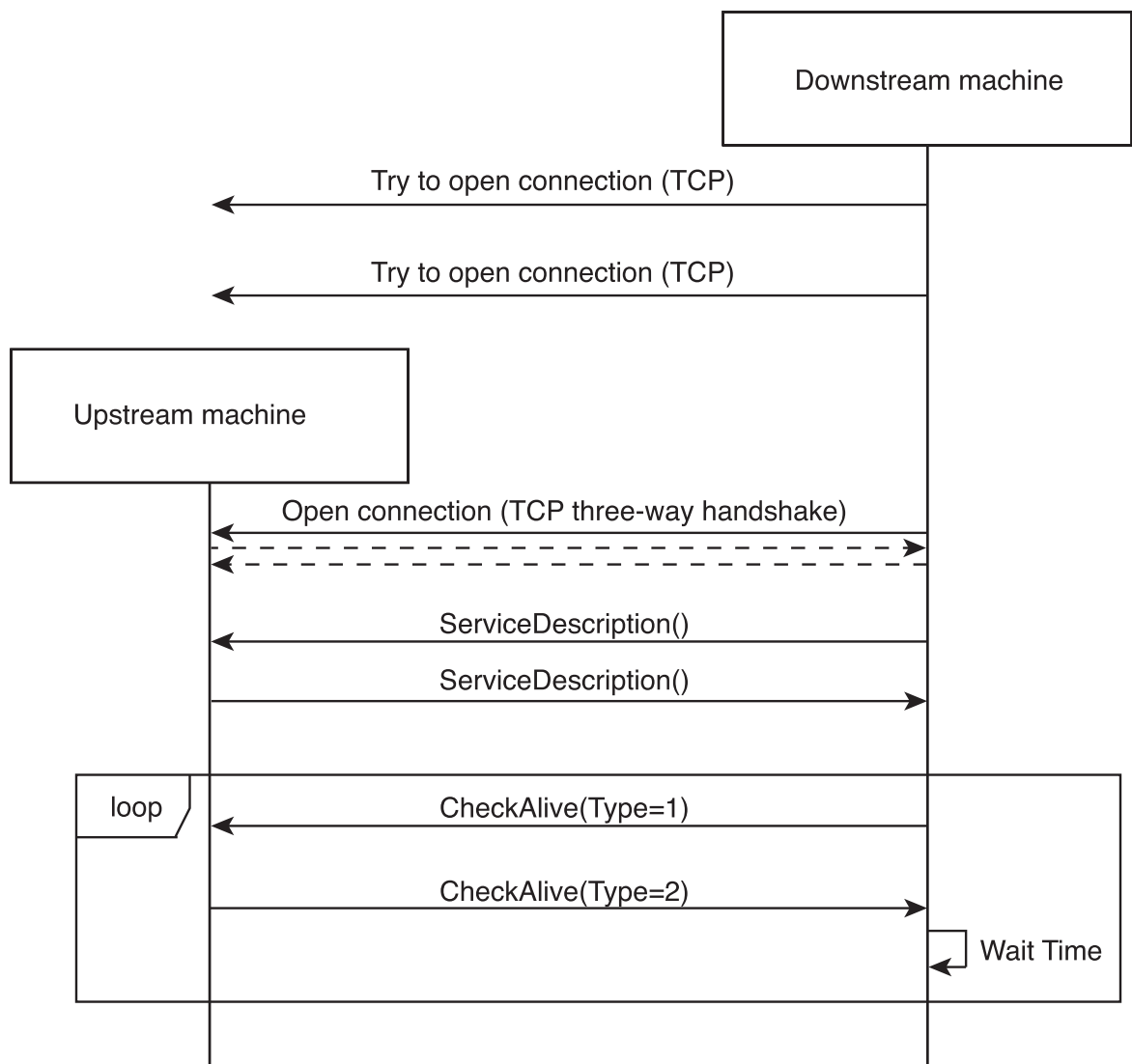


Figure 5 Example for Connection Loss Detection with FeatureCheckAliveResponse on Horizontal Channel

One of the machines (in Figure 5, the downstream machine, but it could be also the upstream machine) sends a (ping) CheckAlive message, that is a CheckAlive message with the attribute Type set to 1. The peer machine then responds immediately with a (pong) CheckAlive message, that is a CheckAlive message with the attribute Type set to 2 and the Id matching the Id of the (ping) CheckAlive message.

A missing response (It is recommended to wait for 3 seconds.) indicates a connection loss.

2.3.3 Normal Operation When an upstream machine has a printed board available for handover, it sends a BoardAvailable message while a downstream machine ready to accept a printed board sends a MachineReady message. The naming of these messages is inspired by the electrical SMEMA interface. However, the messages do not represent the state of a machine’s interface directly but are events for initiating a printed board handover.

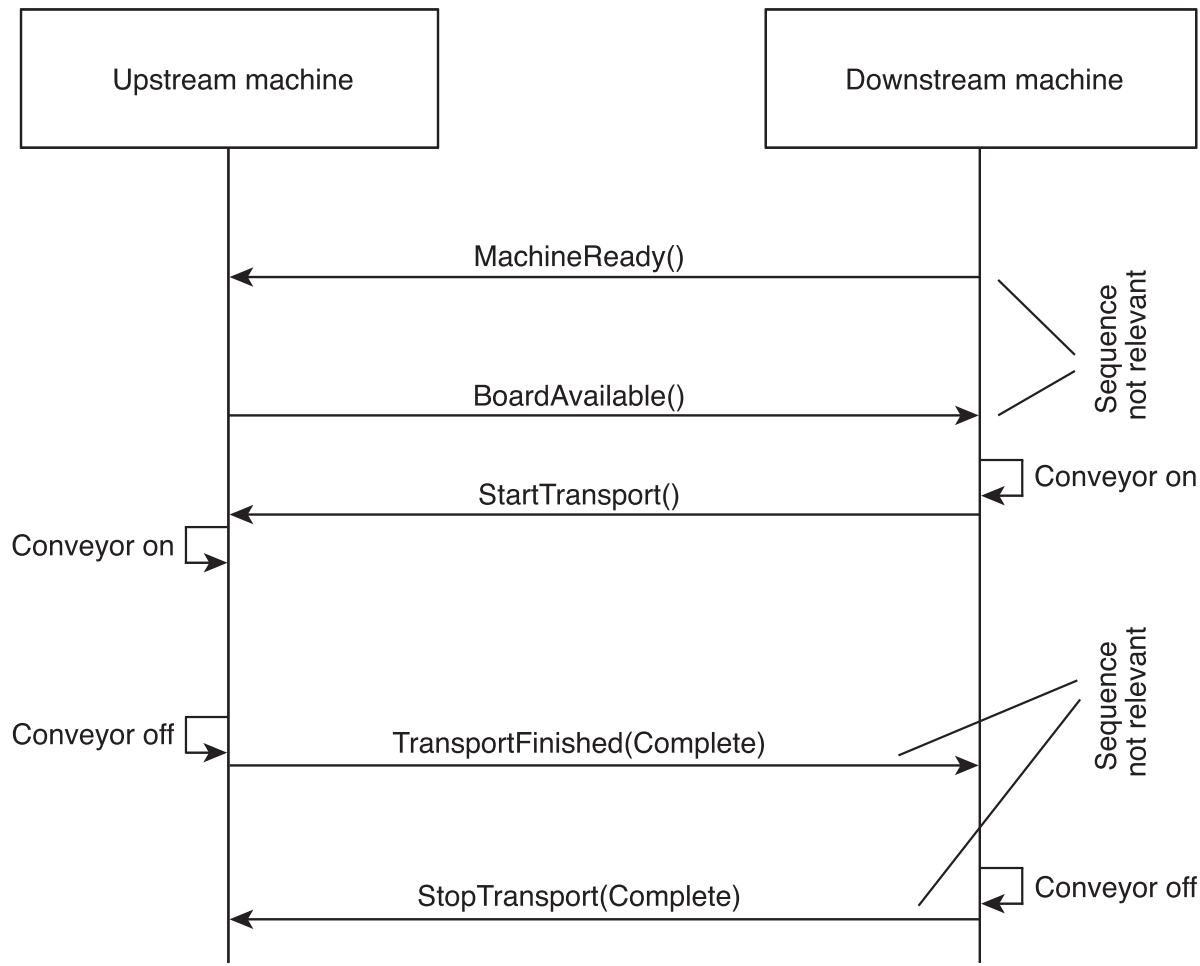


Figure 6 Communication Sequence for Board Transport

When both machines have indicated their readiness to handover the printed board, the downstream machine initiates the transfer by switching on its conveyor and sending the StartTransport message. Upon receiving this message, the upstream machine switches on its conveyor and the printed board moves into the downstream machine.

When the upstream machine is able to state that the printed board has fully left the machine, it sends the TransportFinished message. When the downstream machine has full control of the board, it sends the StopTransport message. The handover of a printed board is finished and is ready to start over.

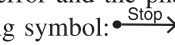
If the upstream machine receives a StopTransport message and has not sent the TransportFinished message yet, it has to stop its conveyor and send the TransportFinished message.

The MachineReady message does not trigger an action on one of the machines directly. However, it still is necessary to realize machines such as shuttles which have to react to the availability of their downstream machines. See Figure 6.

2.3.4 Transport Error Handling To keep this protocol hardware independent, the handling of transport errors is described based on a very simple model of the board handover. The handover process is structured into the three phases:

- 1) NotStarted: The board is fully inside the upstream machine.
- 2) Incomplete: The board is partly inside both machines.
- 3) Complete: The board is fully inside the downstream machine.

Any state or event which prevents one or both machines from handing over a printed board is interpreted as an error. An error may be detected by any of the machines in any of the three handover phases. It is up to the application how to detect the current handover phase, how to detect errors and how to solve them eventually (e.g., sensors, model based prediction, timeouts, user interaction, etc.).

The following sequence charts give an overview of the communication within this protocol depending on the machine which detects the error and the phase in which it is detected. The point in the sequence where the error is detected is marked by the following symbol: 

Scenario U1a

- Error detected by the upstream machine
- Printed board fully inside the upstream machine
- Error detected before StartTransport has been received

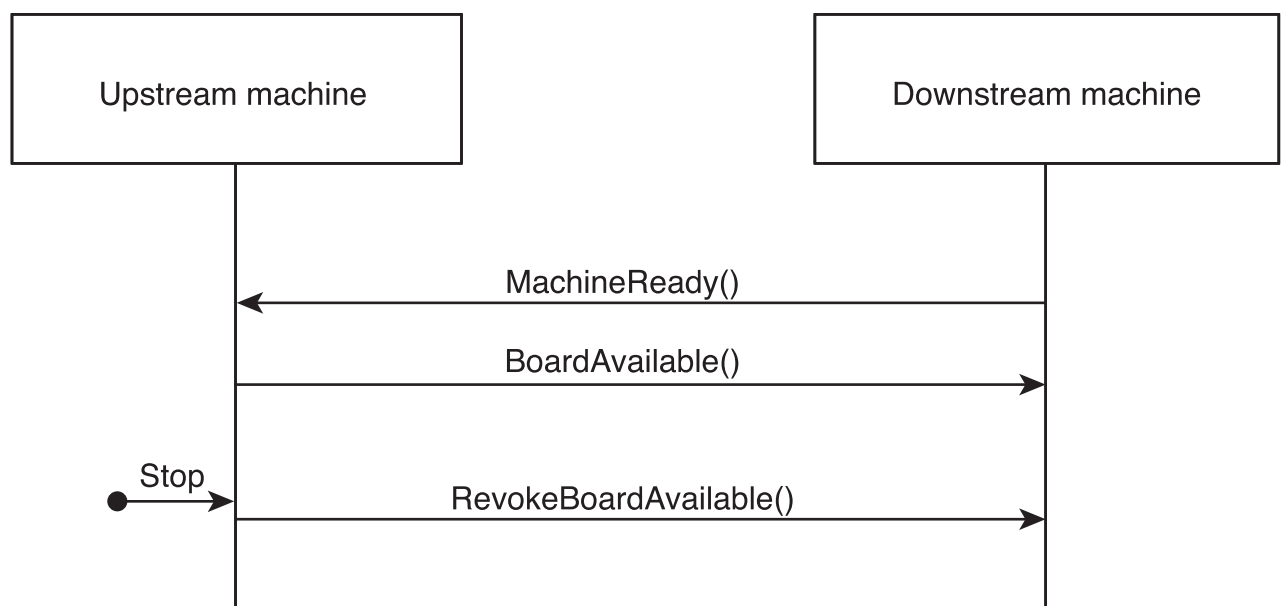


Figure 7 Communication Sequence in Scenario U1a

Error detection: The error is detected before any transport started.

Reaction on upstream machine: The upstream machine sends a RevokeBoardAvailable message.

Reaction on downstream machine: None.

Resolution: After the error is solved, the regular transport sequence can start from the beginning.

See Figure 7.

Scenario U1b

- Error detected by the upstream machine
- Printed board fully inside the upstream machine
- Error detected after StartTransport has been received

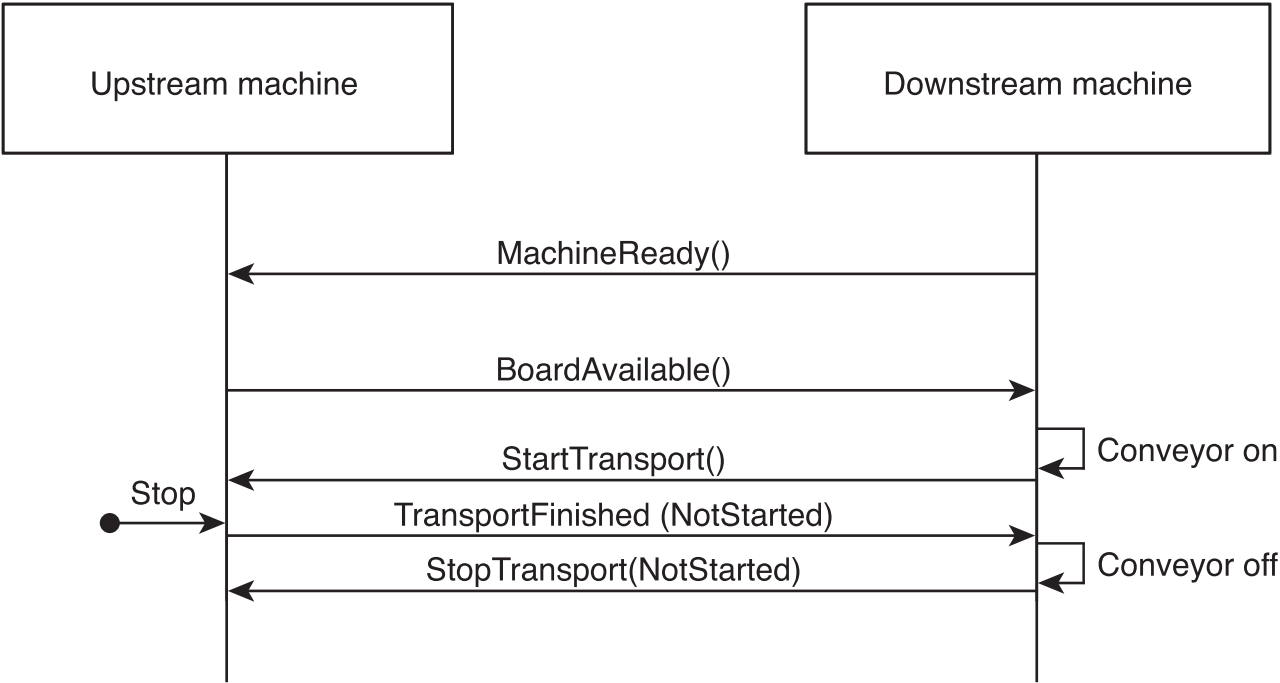


Figure 8 Communication Sequence in Scenario U1b

Error detection: The error is detected after the downstream machine started its conveyor and has sent the StartTransport message.

Reaction on upstream machine: The upstream machine sends a TransportFinished message indicating that it has not started the transport.

Reaction on downstream machine: Upon the TransportFinished message, the downstream machine stops its conveyor and sends a StopTransport message indicating that no transport has started.

Resolution: After the error is solved, the regular transport sequence can start from the beginning.

See Figure 8.