



Productive 4.0

OPC-UA COMPANION FOR SEMI-CONDUCTOR EQUIPMENTS CONTROL

1. Semi-conductor fab automation

- Semi-conductor fabs
- SECS/GEM standards

2. From SECS/GEM standards to OPC-UA companion

- Semi-conductor industry vs Industry 4.0
- OPC-UA information model framework
- From SECS/GEM towards OPC-UA
- The deployment of SECS/GEM OPC-UA companion

3. Perspectives

- Production jobs are launched on aggregated equipment responsible of the execution of the production process
- Some production jobs are fully automated, some others not
- Equipment is controlled by one host (part of the MES)
- The wafer fab is designed as a number of re-entrant flow lines that requires a high flexibility and traceability

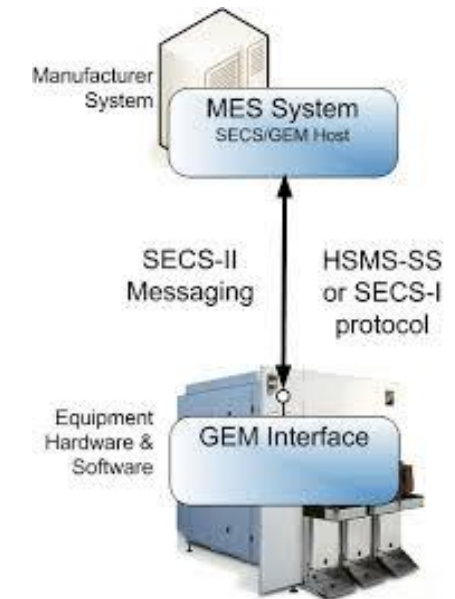


IBM Foundry



Corbeil-Essonne XFab

- SECS/GEM standards specify the interface between the equipment and the host
- Bi-directional Service Oriented Architecture (SOA)
 - **Host → Equipment**
 - start and stop processing
 - select, download and upload recipes from/to the equipment
 - query the equipment for values of various process parameters and equipment configuration
 - set equipment configuration parameter values
 - define reports of various variables and associate them with events such as lot start or wafer complete
 - **Equipment → Host**
 - send alarms, various events and associated reports to the fab host



- E5-SECSII: structure of all messages**

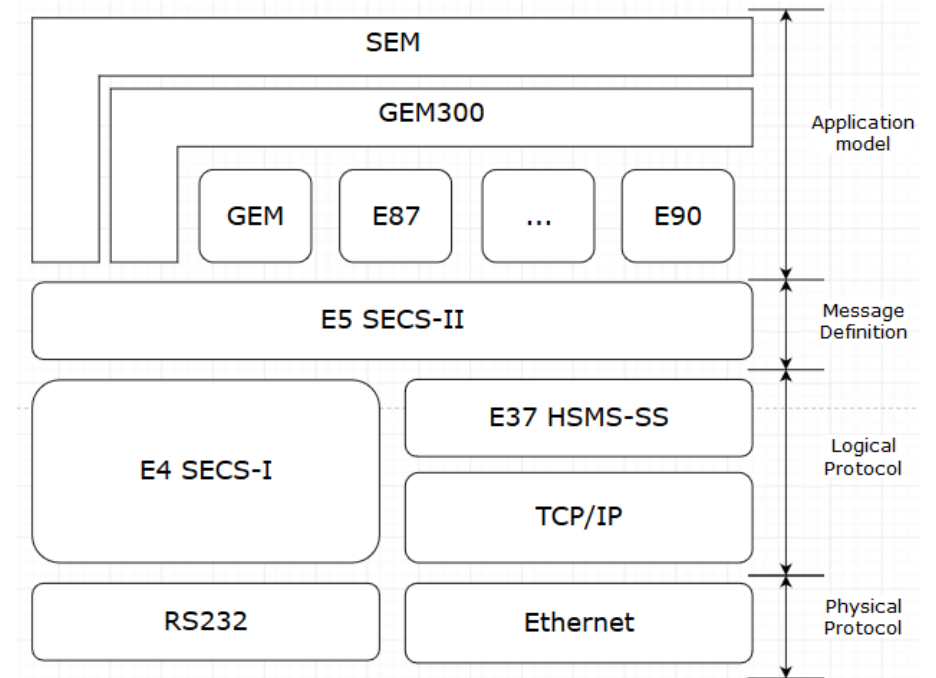
S2F41 H->E SendCommand
L,2

1. <RCMD>
2. L,n # of parameters
 1. L,2
 1. <CPNAME1> parameter 1 name
 2. <CPVAL1> parameter 1 value
 - .
 - n. L,2
 1. <CPNAMEn> parameter n name
 2. <CPVALn> parameter n value

S2F42 H<-E SendCommandAcknowledge
L,2

1. <HACK>
2. L,n # of parameters
 1. L,2
 1. <CPNAME1> parameter 1 name
 2. <CPACK1> parameter 1 reason
 - .
 - n. L,2
 1. <CPNAMEn> parameter n name
 2. <CPACKn> parameter n reason

- E30: Generic Equipment Model**
- E39: Services to access objects**
- E40: Functions related to material processing and processing management**
- E87: Carrier management**
- E90: Specifications for substrate tracking**
- E94: Specifications for control job management**



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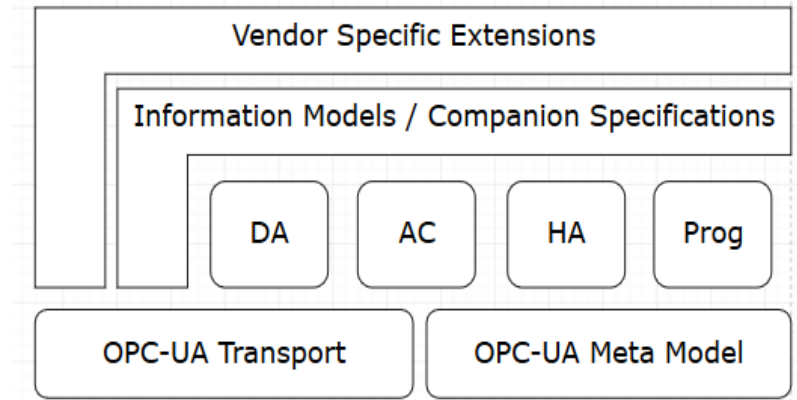
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3. Perspectives

- **Motivation to analyze semi-conductor industry**
 - Semiconductor components will have to be enhanced as Industry 4.0 components integrated within CPPS platforms
 - Semiconductor standards provide fine grained and field proven methods to perform remote control on semiconductor equipment
 - Can be used as solutions and best practices for the remote control of other equipment in other domains
- **INDUSTRY 4.0 introduces new architecture and standards**
 - RAMI 4.0
 - Vertical & horizontal communication
 - 3D cube that can be used to figure out enabling technologies and standards for Industry 4.0
 - OPC-UA
 - Enabling technology allowing independent-platform interoperability
 - Information model framework handling domain concepts

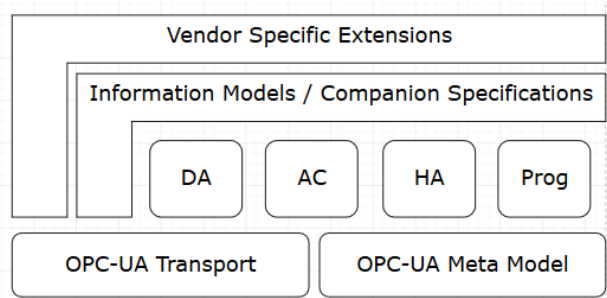
- **Multi-layers framework**

- Transport protocol specification
- Metamodeling based on generic concepts: *View*, *Object*, *ObjectType*, *Variable*, *Method*, *DataType*, *VariableType*, *ReferenceType*.
- Generic IM for data access, alarms management, history management and stateful functionality
- Companion specifications for domain specific companion (generally specified by standardization consortium)
- Vendor specific extensions: proprietary information models (e.g. specific to one equipment)

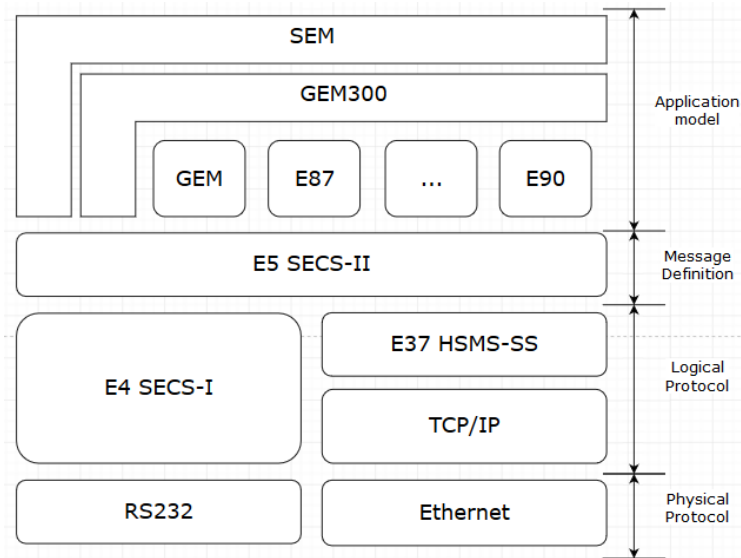


OPC-UA information model framework

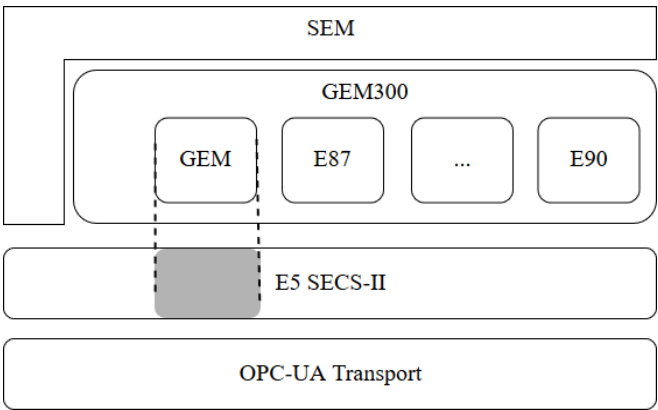
FROM SECS/GEM → OPC-UA



OPC-UA Information Model



SEMI standards stack



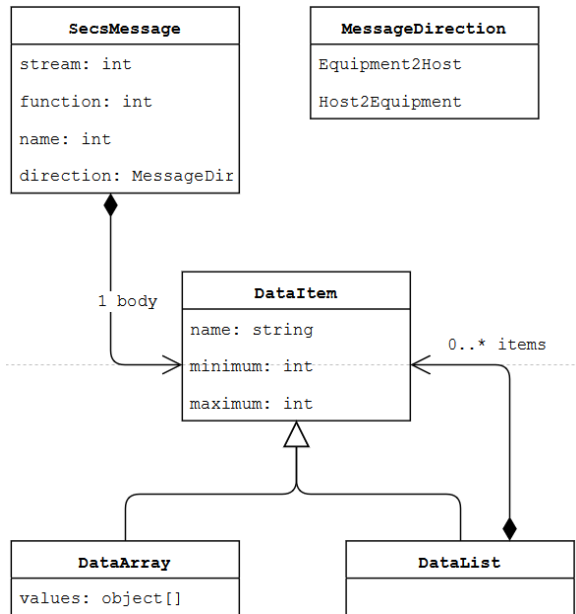
OPC-UA Information Model
handling SECS/GEM
standards

APPROACH TO BUILD GEM OPC-UA COMPANION

- **Definition of a SEMI service**

$$\text{SEMI}_{\text{service}} = \{SxFy, SxFy+1\}$$

- **UML Modeling of a SEMI message**
 - Definition of an abstract syntax of an E5 message
 - Definition of the UML model of E5 message
 - Transformation towards OPC-UA E5 information model
- **Generation of UML GEM interface**
 - Definition of UML GEM interface
 - Transformation towards GEM information model
- **OPC-UA companion deployment**
 - Definition of OPC-UA architecture
 - Deployment of the address space
 - OPC-UA scenario

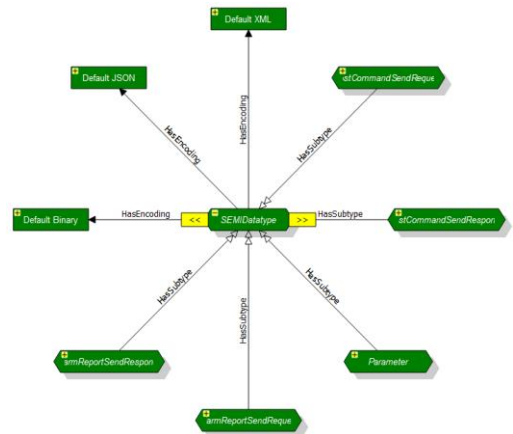
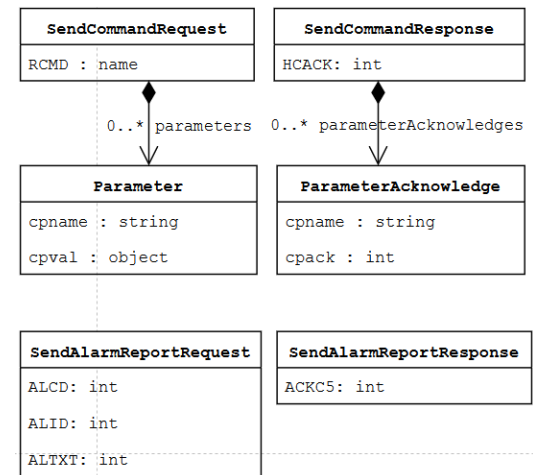


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L, 2

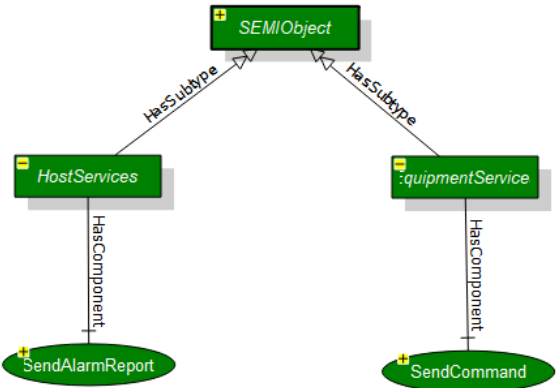
- <RCMD>
- L, n # of **parameters**
 - L, 2 **parameter**
 - <CPNAME1> parameter 1 name
 - <CPVAL1> parameter 1 value
 - ...
 - n. L, 2 **parameter**
 - <CPNAMEn> parameter n name
 - <CPVALn> parameter n value

S2F42 H<-E SendCommandAcknowledge
L, 2

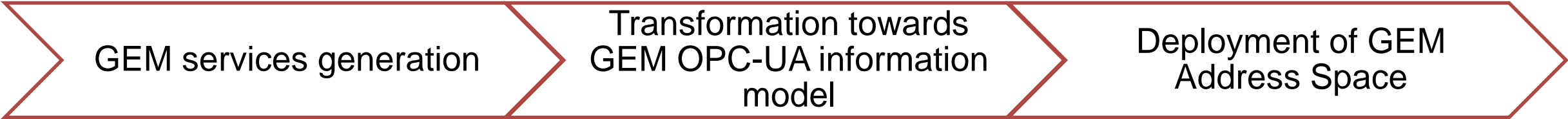
- <HCACK>
- L, n # of **parameterAcknowledges**
 - L, 2 **parameterAcknowledge**
 - <CPNAME1> parameter 1 name
 - <CPACK1> parameter 1 reason
 - ...
 - n. L, 2 **parameterAcknowledge**
 - <CPNAMEn> parameter n name
 - <CPACKn> parameter n reason

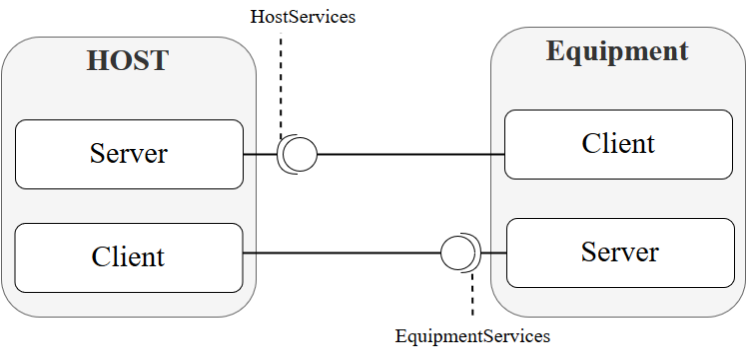


EquipmentGEMServices
SendCommandResponse SendCommand(SendCommandRequest request)
HostGEMServices
SendAlarmReportResponse SendAlarmReport(SendAlarmReportRequest request)

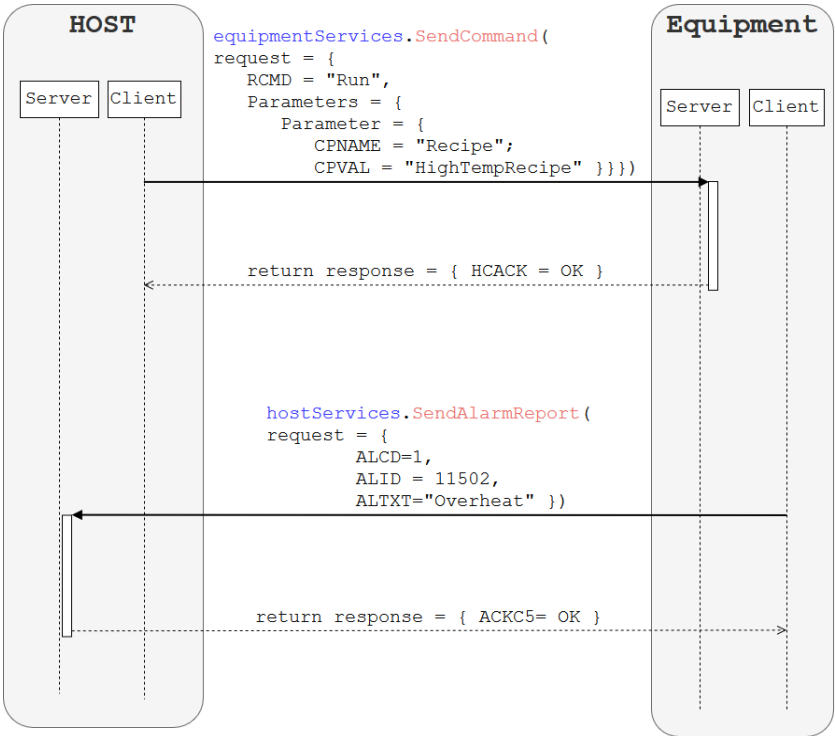


- SEMI Datatype
 - AlarmReportSendRequest
 - ALCD [UInt32]
 - ALID [UInt32]
 - ALTXT [String]
 - AlarmReportSendResponse
 - ACKC5 [UInt32]
 - HostCommandSendRequest
 - RCMD [UInt32]
 - parameters [ArrayOfParameter]
 - HostCommandSendResponse
 - HCACK [UInt32]
 - parameterAcknowledges [ArrayOfParameterAcknowledge]
 - Parameter
 - CPNAME [String]
 - CPVAL [BaseDataType]
 - ParameterAcknowledge
 - CPNAME [String]
 - CPACK [UInt32]





- ▼ **SEMIOObject**
- ▼ **EquipmentServices**
- > **SendCommand**
- ▼ **HostServices**
- > **SendAlarmReport**



Definition of OPC-UA
Architecture

Browsing Host and
Equipment Interfaces

OPC-UA Information
Model in action

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3. Perspectives

- **Submission to ETFA 2019**
- **Demonstrator**
 - OPC-UA emulation of an equipment remote control based on our information model
- **Arrowhead integration**
 - How to use the OPC-UA companion within Arrowhead framework ?

