Sensor Interface based on Ethernet/IP as Network Communication Standard SEMI E54.13

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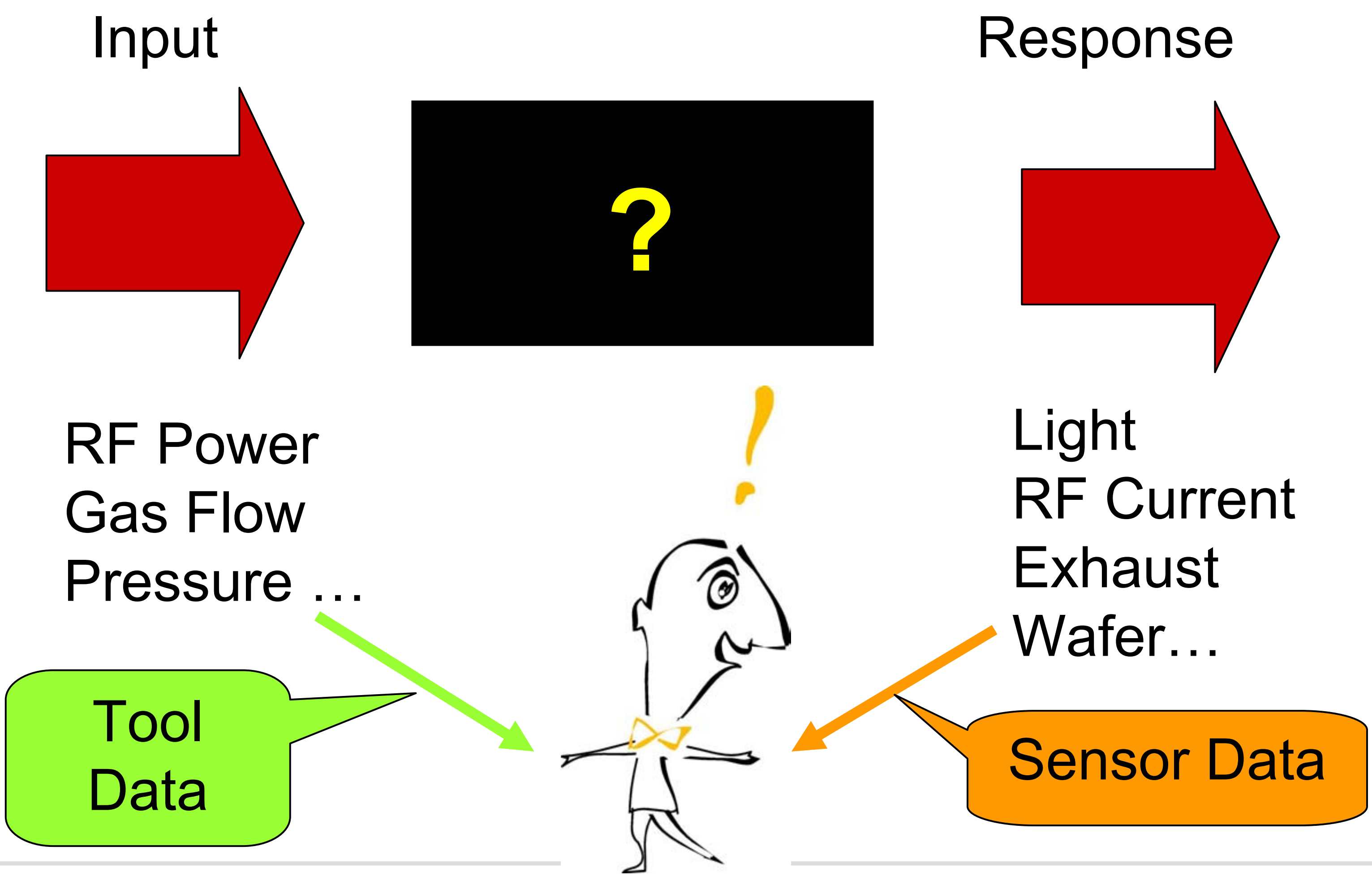
Contents

- Why additional Sensors?
- Sensor Interfaces and its Properties
- Standard of Interfaces
- Ethernet/IP
- Implementation of Sensor Interfaces
- Summary

Why do we need additional Sensors?

Black Box Experiment



More Information about the Process

- Keeping all tool data constant does not mean that all boundary condition of the system "process" are fixed.
- An important influence have properties of the chamber wall and the wafer.
- External sensors give information about unknown boundary condition implicitly by investigating the response of the system. Some kind of sensors deliver data with physical meaning because of their physical model behind.
- Hard parameters of additional sensors for data compression needed.

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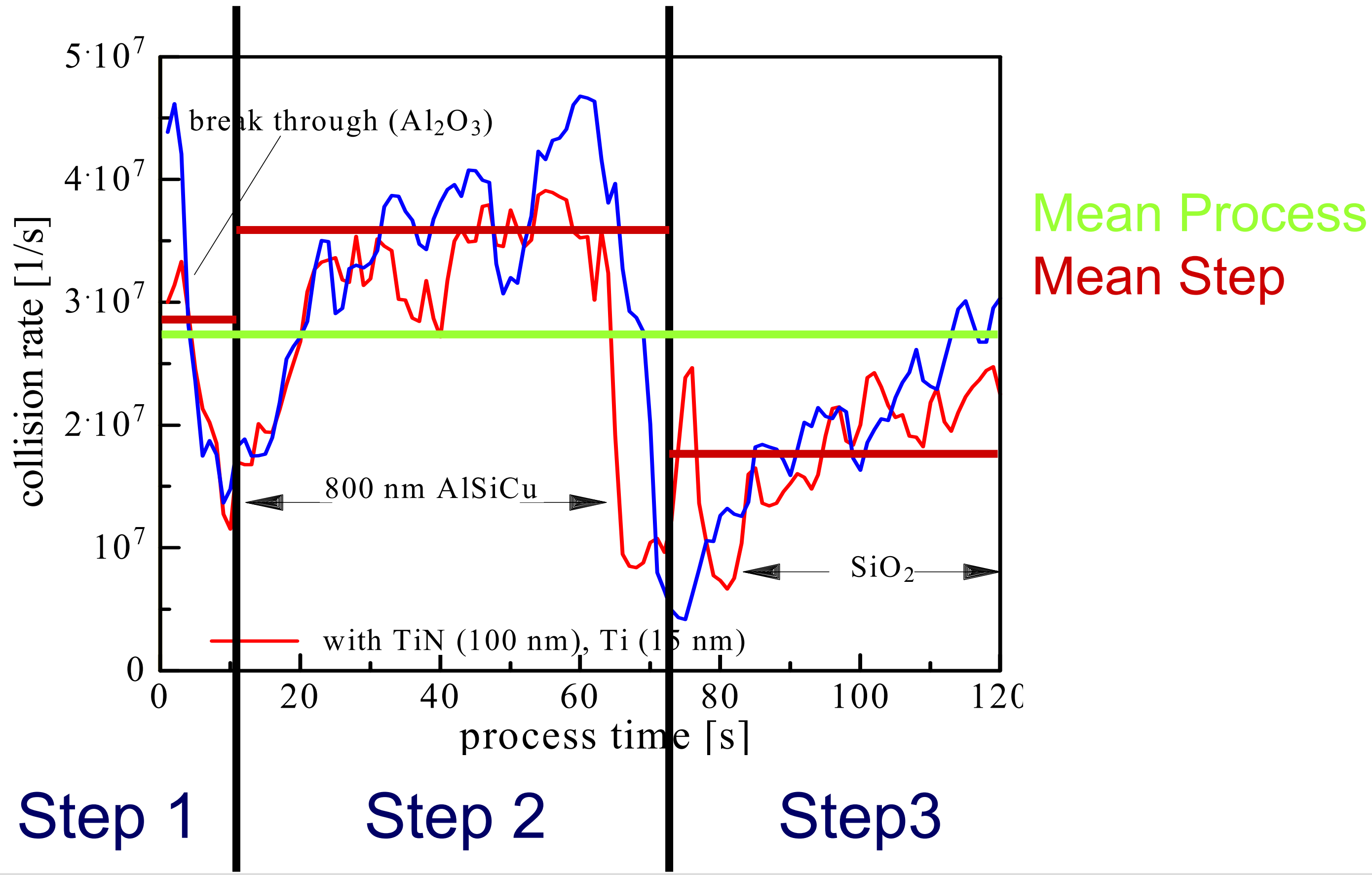
Why Sensor Interface?

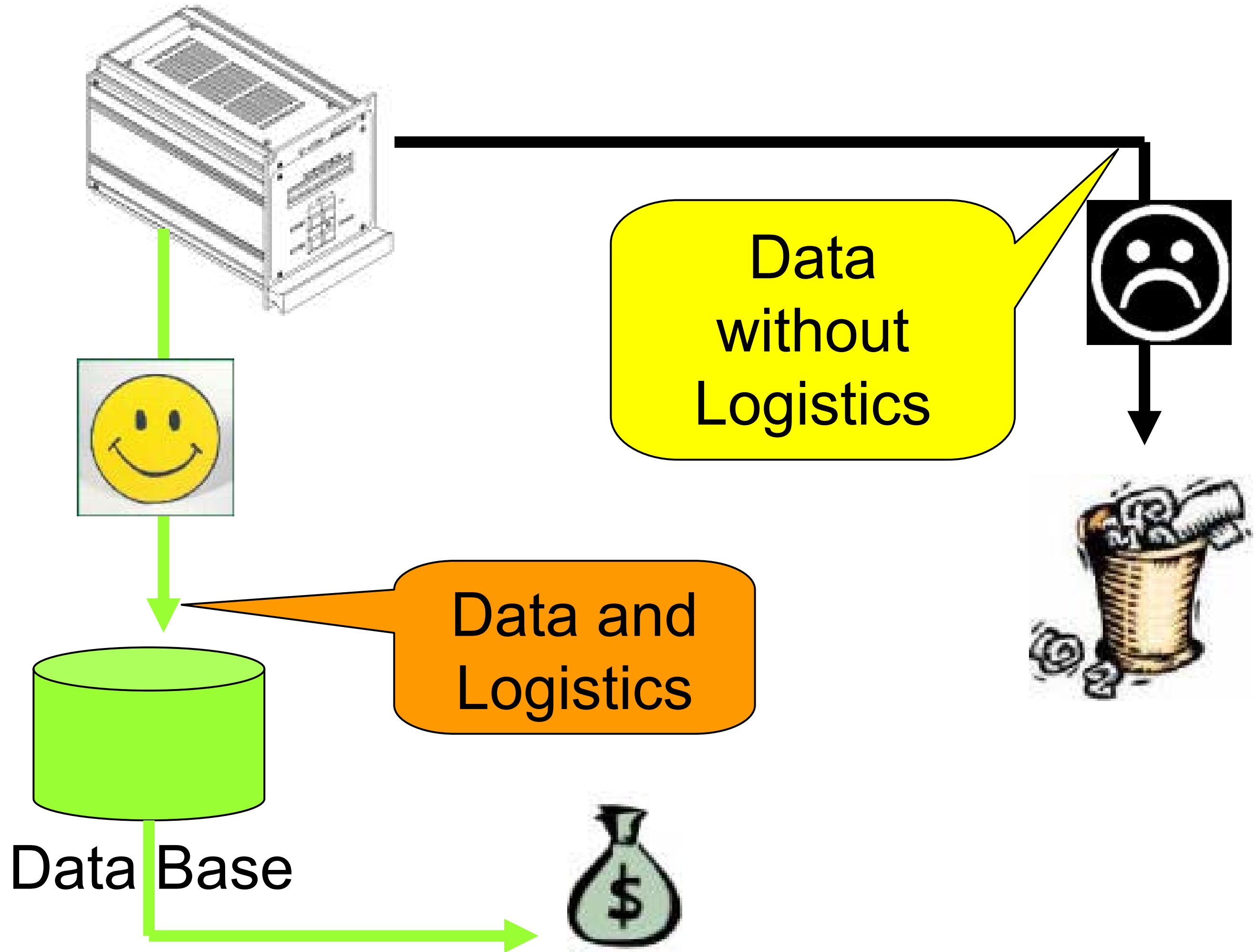
- High volume production: 10MB per chamber a day
  - Data reduction necessary for analysis
  - High speed data transfer
- Automatic Data Analysis
- Process step should be known
  - Stepwise data reduction
    - i.e. the mean of process data of the whole process is different from the mean of each process step.
- Transfer of Logistics:
  - LotID, Recipe, Process Step, WaferID
    - Necessary for identifying the data
  - Some kinds of sensors need to know the recipe, because the algorithm of calculating the sensor data depends on the process.
- Time synchronisation between tool data and sensor data.
  - If both data sources have different time scales it will be very difficult to compare in case of fault detection!

Logistics: Process Step

Mean of the whole process is different from the mean of each recipe step.



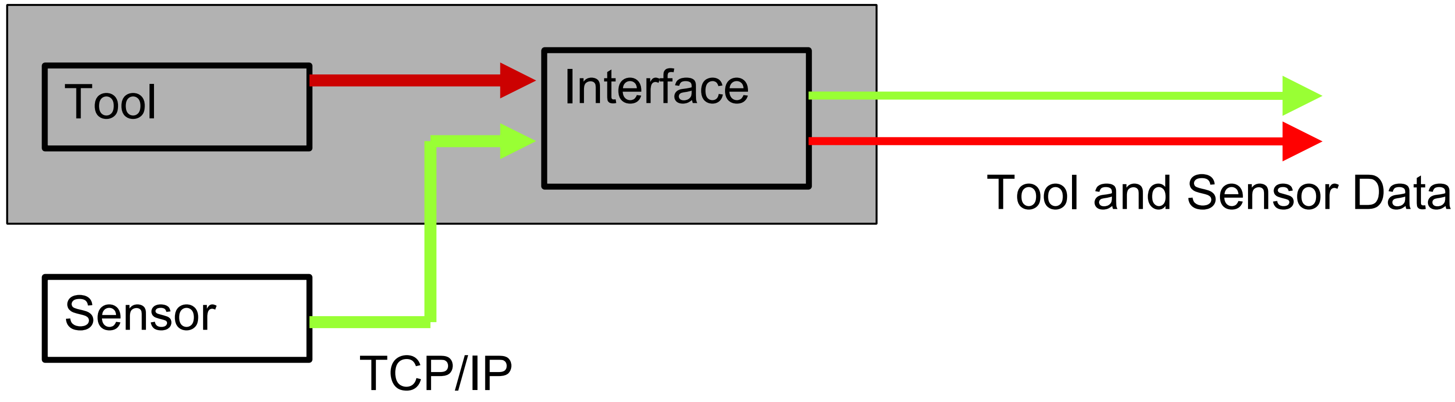
No Revenue without Data Coupling



Requirements on Sensor Interface

- The sensor data has to appear as coming from the tool
- Plug and Play functionality
  - Sensor identifies itself when connecting to the interface.
  - Auto-reconfiguration after shut down of the interface.
  - „Hearth Beat“ for periodical check of the connection.
- Transfer of „Logistics“ to the sensor.
- Sensor may send endpoint and alarm events.
- Ethernet based
- SEMI Standard

All requirements complied by SEMI E54.13 (Ethernet/IP)



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Requirements on Sensor Interface

- Response time < 150 ms
- Common Hardware usable
- SEMI Standard
  - A standardised interface guarantees a wide range of sensor devices, which could be integrated easily.
- Protocol feature:
  - Self identifying, Plug and Play
  - Hearth Beat
  - Time synchronisation and time stamp
  - Logistic
  - Error Handling
  - Events

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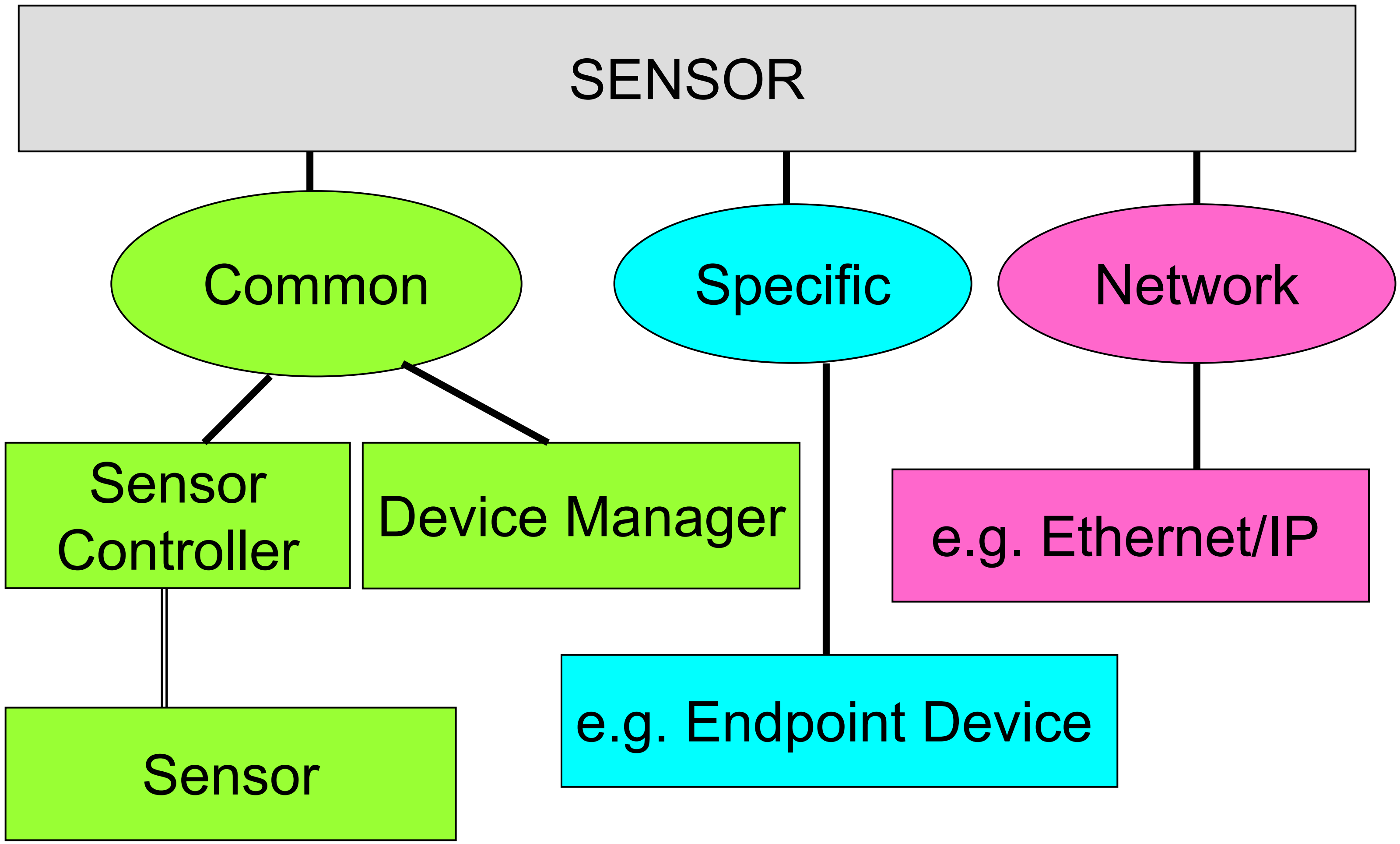
Why Ethernet/IP?

- Based on Ethernet
  - Common Network Cards usable
  - All Operating Systems supported
  - Response time sufficient
- No sensor specific item must be added
  - Easy integration of sensors into the network
  - Transfer of logistics included
- Easy integration of sensors to existing DeviceNet application (gateway).
  - Sensor data will appear as tool data!
- The standard compliance will be guaranteed by a vendor organization.

Object Model of SEMI E54



Source: SEMI E54

SEMI E54.1 Common Device Model

Required Objects:

- Sensor/Actuator Controller Object (SAC)
  - Coordinates the interaction of the device with the environment
- Device Manager Object
  - Manages the device operation. It contains information of the device: Device type, device status, alarms, events.
- Sensor Object
  - Contains the value of the sensor without further information about it. The value descriptor and the data type should be defined in the specific device model (SDM).

Each Device of the network must comply with the Common Device Model (CDM).

The common properties of CDM are not sufficient to define a sensor, which only delivers data and does not need further control.

SEMI 54 Specific Device Model

- Description of specific properties of a sensor.
  - Available SDM:
    - MFC
    - Endpoint Device
    - In-Situ Particle Monitor Device
- Object Mapping
  - How the objects and relations fit into the protocol application layer.
- Lack of this Model: The master of the sensor bus has to know each Specific Device Model (SDM), in general that is only possible for devices which have SDM defined in the standard, e.g. MFC etc.

Plug and play not guaranteed for classes of sensors.

Semi E54:Different Network Communication Standards Possible

Network Communication Standard

DeviceNet SDS LonWorks SeriPlex Profibus DP CC-Link	Ethernet/IP Modbus/TCP
10 ms Response	100 ms Response
Special Hardware	Common Hardware
Tool Level	Sensor Level

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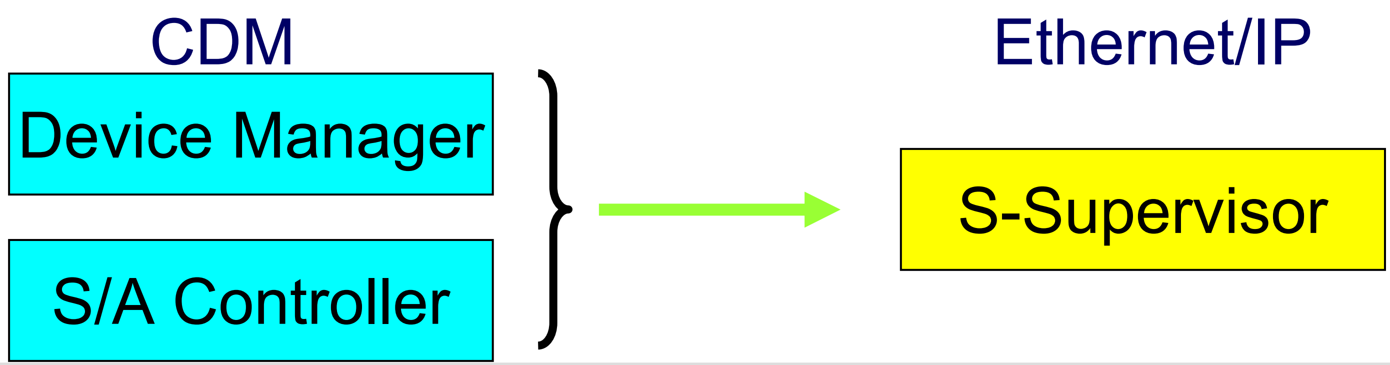
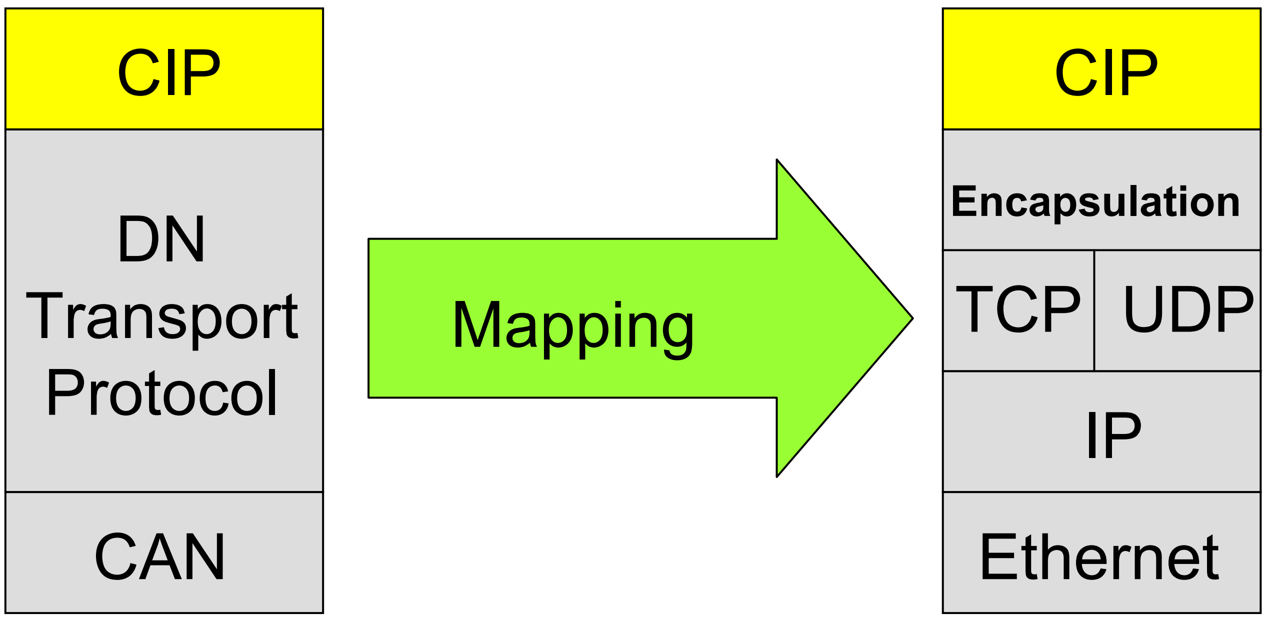
SEMI E54.13 – Ethernet/IP

- Specifies a Sensor Actuator Network (SAN) Communications Standard based on the Ethernet/IP specification enabling communication with SAN devices configured according to SEMI SAN Common Device Model (CDM).
- SEMI E54.13 maps all Common Objects to the open Ethernet/IP standard.



Ethernet/IP

- Ethernet Industrial Protocol (EIP)
  - Control and Information Protocol (CIP) over TCP/IP
  - Mapping DeviceNet (DN) to TCP/IP
  - Easy coupling of DN and EIP!



Source: CIP Specification, ODVA

Advantages of Control & Information Protocol

- Open DeviceNet Vendor Association ODVA controls all Vendors of Control & Information Protocol (CIP) applications to comply to the standard.
- Further enhancement of the standard by the user association guaranteed.
- DeviceNet is the dominant standard of field buses in northern America using also CIP.
- Many experiences and applications in semiconductor industries
- Object standards for semiconductor devices available
- Cost effective solution to bridge from Ethernet/IP to DeviceNet or vice versa
- Open standard
- Free code available

Control and Information Protocol

- Transfer of Control and Information Massages
  - Control Message: Short, fast, unacknowledged Message, transferring real-time data, e.g., sensor data. Transfer via UDP.
  - Information Messages: Longer, error ensured, non-real-time message, e.g., configuration and diagnostics. Transfer via TCP.
- CIP makes use of abstract Object Model to describe:
  - Suite of communication services available
  - Externally visible behaviour of a CIP node (Sensor device)
- Consumer – Producer Architecture:
  - Producer sends messages as broadcast. The interested consumers read the message.

CIP Device Model of a Sensor

- Model of an intelligent sensor which only produces data and does not requires further control.

Common Sensor Device

S-Device Supervisor/ Identity

Analog Sensor (Data, Data Type)

S-Substrate* (Logistics, Trigger)

Assembly (Data, Time stamp)

* pending Specification Enhancement introduced to ODVA by ASI

S-Analog Sensor Object - Attributes

- Selection of Attributes of the S-Analog Sensor Object
  - “S” reads for Semiconductor.
  - A number of 37 attributes defined for this object.

Name	Description	Access
Data type	Data type of value	read
Data unit	Unit of value	read
Reading value	Value valid?	read
Value	Sensor value	read
Value descriptor	Name of value	read

Each instance of the S-Analog Sensor Object represents a value of the sensor!

Source: CIP Specification, ODVA

S-Substrate Object - Attributes

- Represents the properties of a Substrate. It contains the logistic Information.
- The change of “Process State” should be uses as trigger of the production of sensor data.

Name	Description	Access
LotID	Lot name	read
RecipeID	Recipe name	read
Recipe Step	Process step	read
SubstrateID	Wafer number etc.	read
Process State	In Process | Process complete	read

Source: CIP Specification Enhancement 849-03-01, ASI

Assembly Object - Attributes

- Is a container of attributes of different objects. It should contain all values of the instances of the S-Analog Sensor Object and the time stamp in our case. The time stamp is a attribute of the S-Supervisor Object.

Name	Description	Access
Time Stamp	Sensor Clock	read
Value 1	Sensor Data	read
Value 2	Sensor Data	read
…	Sensor Data	
Value n	Sensor Data	read

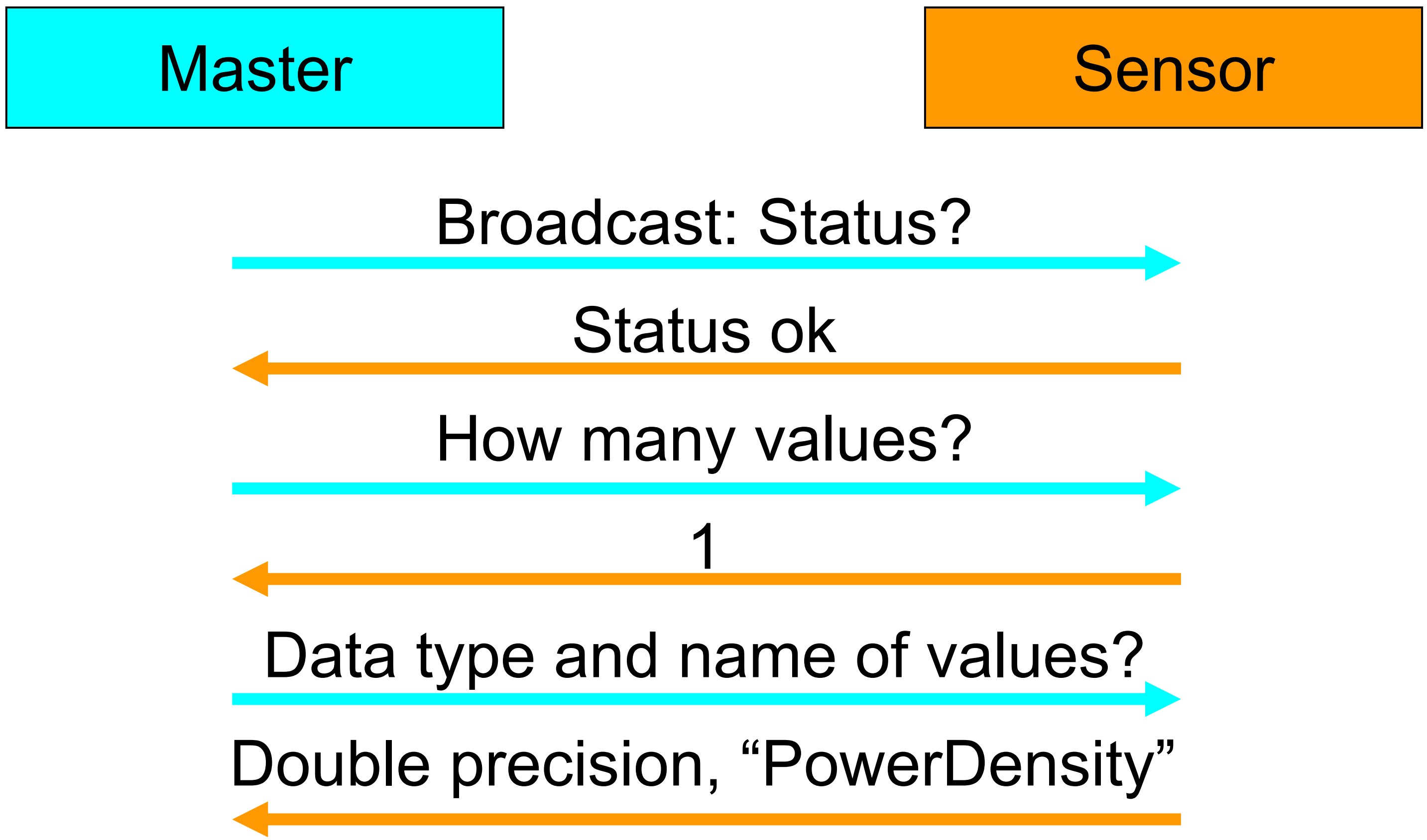
Source: CIP Specification, ODVA

No additional specific Properties

- The objects of CIP (Ethernet/IP) introduced are sufficient to establish a fully featured communication within a SAN.
- There is no need to define further specific objects, like SDM of SEMI 54. This makes the integration of intelligent sensors more easier, because the master of the sensor network must not know the specific properties of each sensors or classes of sensors respectively. The properties of the sensor will be reduced to its data, i.e. to essential attribute.
- The plug and play functionality has to be managed by the master of the sensor network.

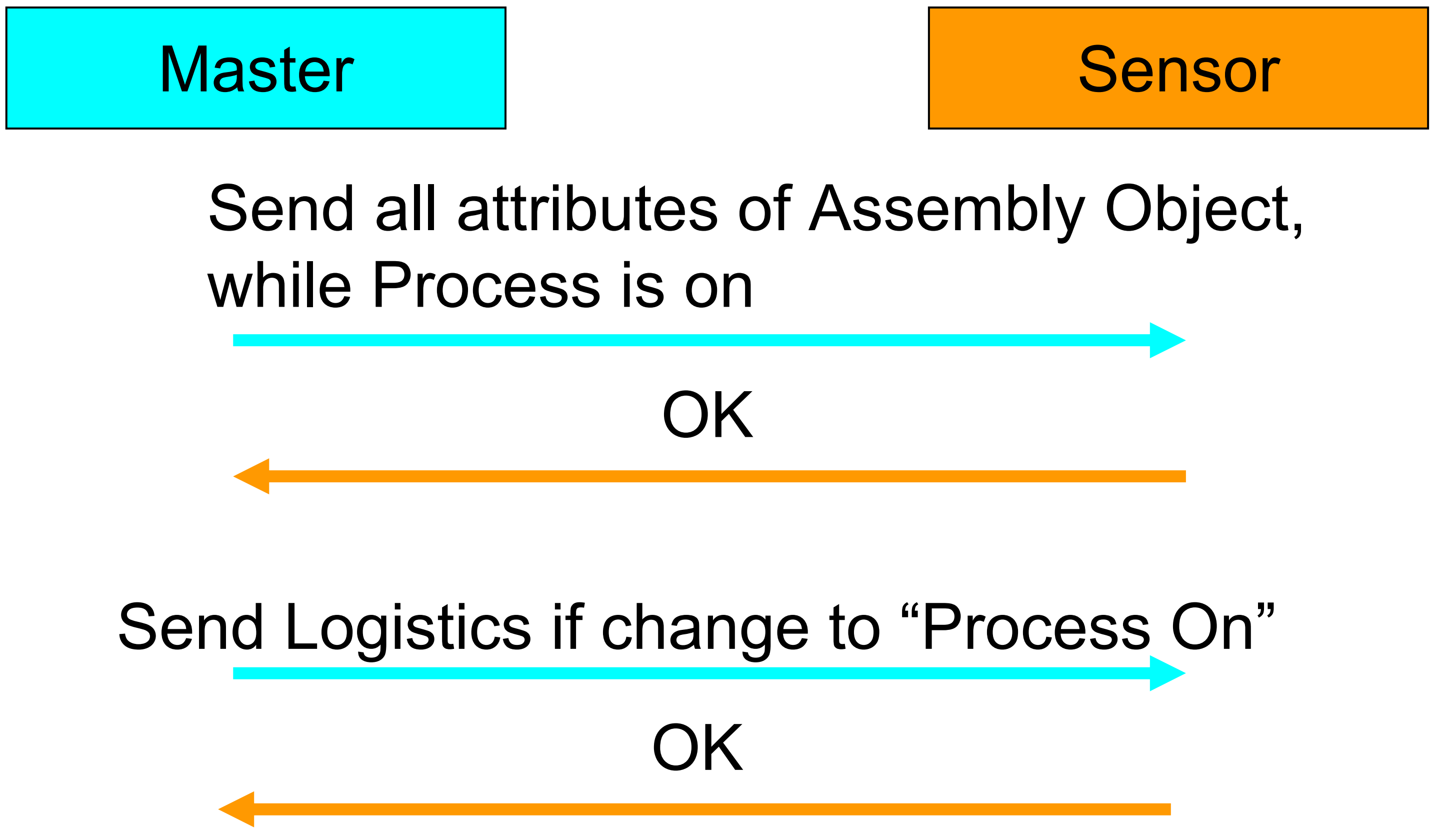
Self identifying of a Sensor

- The plug and play function has to managed by the master.



Data Collection and Logistics

- The Assembly Object contains all data and the time stamp.



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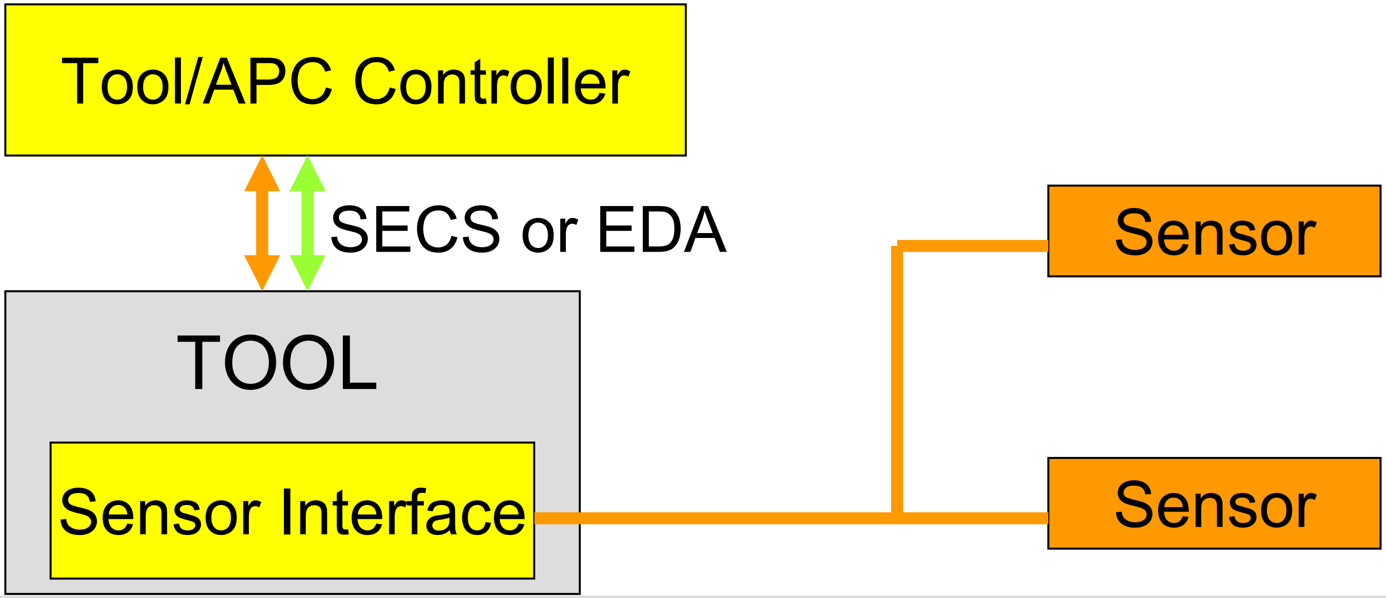
Integration of a Sensor Interface

- Use the sensor interface integrated by the tool supplier.
- Adding a sensor to the DeviceNet network using a gateway.
  - The configuration is possible in terms of a EDS (Electronic Data Sheet) file.
  - Sometimes dynamical relation of sensor data to status variables possible. The sensor data would appear as tool data.
- Using a “BOX” which acts as master of the SAN and as SECS-relay.

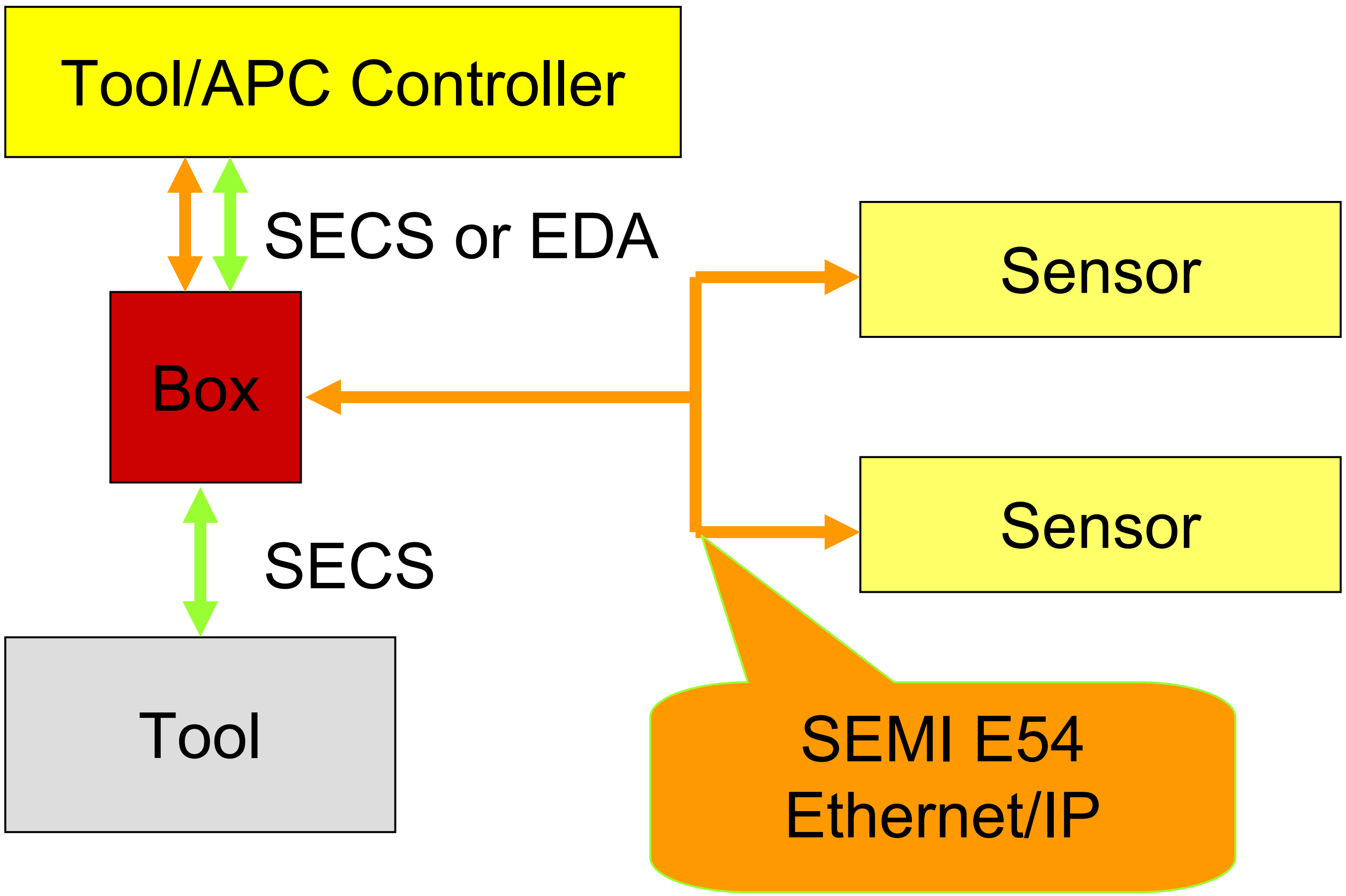
Sensor Interface integrated in the Tool

- The best solution is to have a sensor interface integrated in the tool.
  - No temporal shift between tool data and sensor data
  - Sensor data traceable via the tool (SECS, EDA)
  - No additional effort (Software, Hardware)
  - Just plug and play



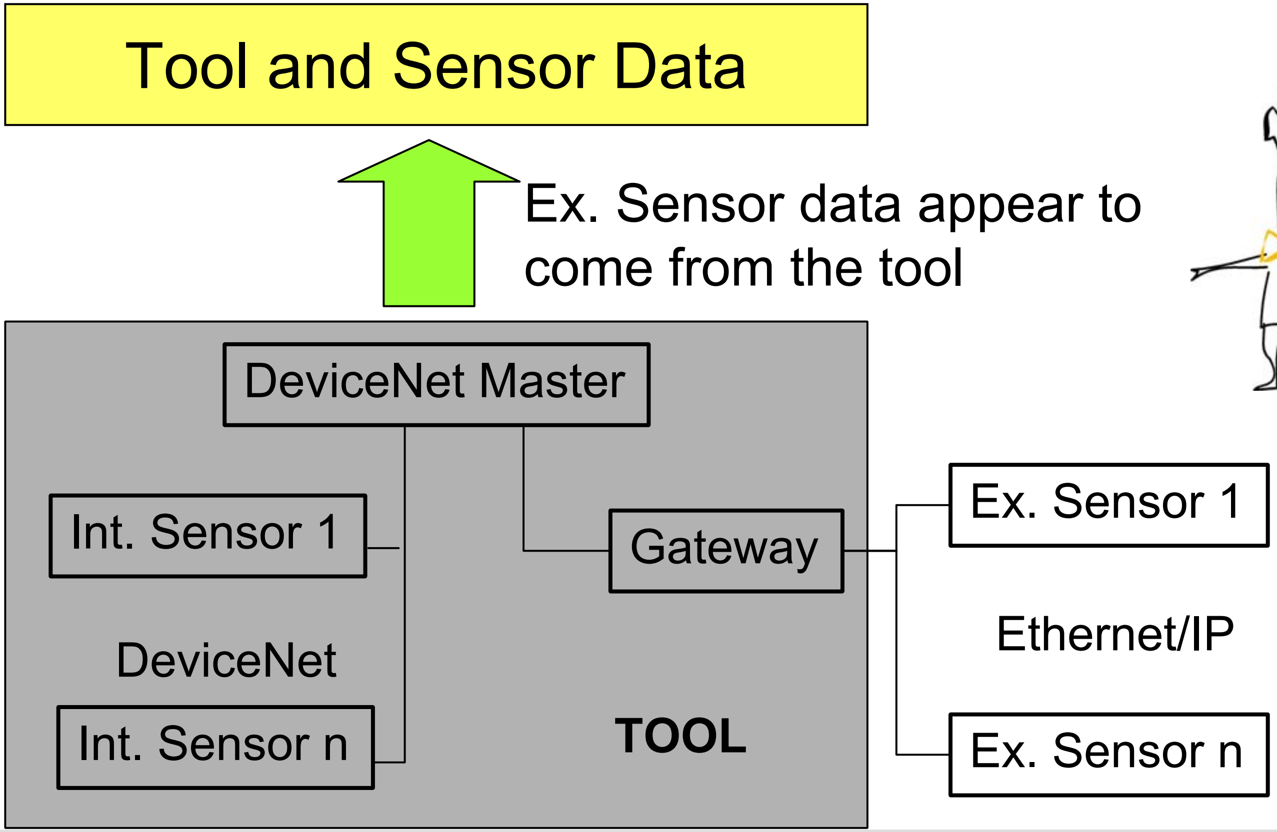
Sensor Interface with “BOX”

- Box as SECS-relay and SAN-master



Gateway to the Tool's SAN

- Proposal of a SAN on Basis of E54.13 integrated in a tool with internal DeviceNet bus.



Requirements fulfilled

Requirements	Ethernet/IP
Plug and Play	supported
Logistics	S-Substrate Object
Time Synchronisation	S-Supervisor Object
Hearth Beat	Identity Object
Events and Exceptions	supported
Trigger of data production	Trigger on “Change of State” Event

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Summary

- Additional Sensors are necessary for a more effective process control and fault detection.
- A standardized sensor interface is an important requirement to:
  - Transfer sensor data and logistics (LotID etc.)
  - Unify tool data and sensor data on the same time base
  - Create the basis of automatic data analysis
  - Easy Integration of additional sensors (Plug and Play)
- Ethernet/IP (SEMI E54.13) has been found to meet all requirements on the communication protocol from practical view.
  - The common objects of CIP include all necessary properties. No further specific objects or attribute have to be defined, i.e. the master of the SAN must not know specific properties of all sensors (great advantage!).
- The interface has to be integrated in the production tool.
  - E.g., gateway DeviceNet – Ethernet/IP
  - “Box” as SAN Controller

Thank you for your Attention