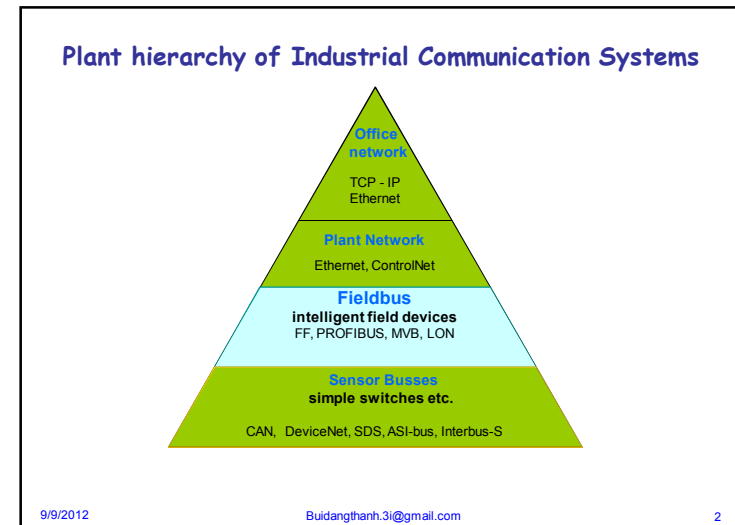





INDUSTRIAL COMMUNICATION SYSTEMS

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What is a Fieldbus?

- ❑ A Fieldbus is an industrial computer network for real-time distributed control.
- ❑ A complex automated industrial system usually needs an organized hierarchy of controller systems to function.
- ❑ Human Machine Interface (**HMI**) at the top, Programmable Logic Controllers (**PLCs**) in the middle, and the **Fieldbus** at the bottom.
- ❑ The Fieldbus links the PLCs to the components which actually do the work such as sensors, actuators, electric motors, console lights, switches, valves, and contactors.

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What is a Fieldbus?

- ❑ Fieldbus is a generic term that describes a new digital communications network that is being used in industry to replace the existing 4-20 mA analog signal standard.
- ❑ The network is a digital, bi-directional, multi-drop, serial-bus communication network used to link isolated field devices, such as controllers, transducers, actuators and sensors.
 - ❑ Bi-directional means it is a duplex port; the data can be transmitted in two directions at the same time.
 - ❑ Multi-drop is also referred to as multi-access and it can be interpreted as a single bus with many nodes connected to it.
 - ❑ Serial-bus means the data is transmitted serially according to RS232 or RS485 protocol. Profibus uses RS485 protocol.

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What is a Fieldbus?

- ❑ Fieldbus works on network structures such as daisy-chain, star, ring, branch, and tree network topologies.
- ❑ Previously computers were connected using RS-232 by which only two devices could communicate.
- ❑ This is the equivalent of the currently used 4-20 mA communication scheme which requires that each device has its own communication point at the controller level
- ❑ The fieldbus is the equivalent of the current LAN-type connections, which require only one communication at the controller level and allow multiple (100's) of analog and digital points to be connected at the same time.
- ❑ This reduces both the length of the cable required and the number of cables required.

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History & Current State

- ❖ In 1999 a committee formed the IEC 61158 standard with eight different protocol sets:

- | | |
|--------------------------|---------------------------|
| ■ FOUNDATION Fieldbus H1 | ■ FOUNDATION Fieldbus HSE |
| ■ ControlNet | ■ Interbus |
| ■ PROFIBUS | ■ SwiftNet |
| ■ P-Net | ■ WorldFIP |

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History & Current State

- ❑ Recent additions or planned additions to IEC 61158 include but are not limited to:
- ❑ PROFINET IO
- ❑ EtherCAT
- ❑ Both FOUNDATION Fieldbus and Profibus technologies are now commonly implemented within the process control field, both for new developments and major refits. In 2006, China saw the largest FF systems installations at NanHai and SECCO, each with around 15,000 fieldbus devices connected

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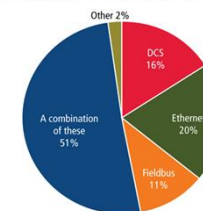
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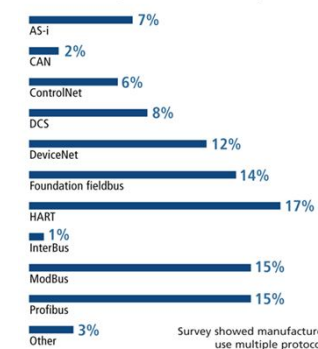
Who uses Fieldbuses?

- Those who plan complex automated industrial systems

Combo pack
The industry likes to use a combination of protocols.



Bus fare
Which of these protocols or networks do you use?



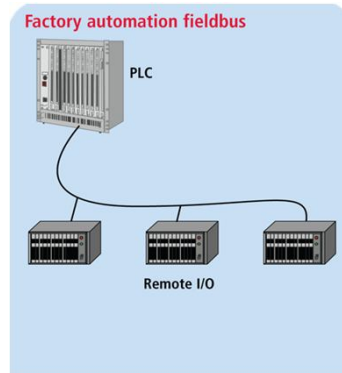
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Where are Fieldbuses Used?

- In complex automated industrial systems where an organized hierarchy of controller systems is needed.
- In manufacturing plants where many instruments need to be connected.



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What are Fieldbuses Used For?

- ❑ When fieldbuses work in the factory, the purpose has been to reduce installation cost by moving the I/O interface from the programmable logic controller (PLC) to a remote I/O unit mounted close to the machine on the factory floor.
- ❑ Factory automation fieldbuses are fast and deterministic. (Deterministic means the maximum worst-case time to obtain data across the fieldbus is accurately predictable and is not subject to chance.)

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When are Fieldbuses Used?

- ✓ When the advantages of Fieldbuses, discussed on the next slide, are needed
- ✓ When the disadvantages of Fieldbuses, on the slide after that, do not hinder use

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Advantages of Fieldbus

- ❑ A major advantage of fieldbus is the capital expenditure (CAPEX) savings associated with cable elimination; multiple devices share wire-pairs in order to communicate over the bus network and savings are also available through speedier commissioning.
- ❑ On going maintenance and process control system performance are significantly enhanced through fieldbus systems, which results in operations expense savings (OPEX).

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Disadvantages of Fieldbus

- ❖ Disadvantages of fieldbus compared to the 4-20 mA analog signal standard:
 - Fieldbus systems are complex, so more training needed
 - The price of fieldbus components is higher
 - Fieldbus test devices are more complex
 - Device manufacturers have to offer different versions of devices due to different fieldbus standards. This can add to the cost of the devices and increases the difficulty of device selection.
 - Standards may predominate or become obsolete, increasing the investment risk.

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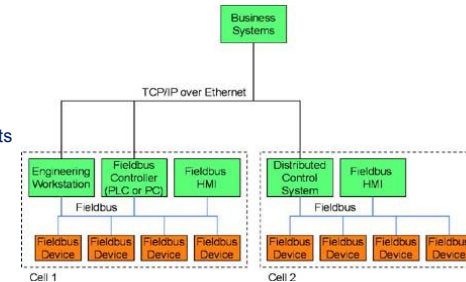
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Costs

- (CAPEX) Savings
- (OPEX) Savings
- Cost of Devices
- Investment Risks

Typical Modern Industrial System

- Engineering costs
- Equipment costs
- Installation costs
- Commissioning costs
- Maintenance costs
- Operating costs
- Inventory costs
- Retooling costs



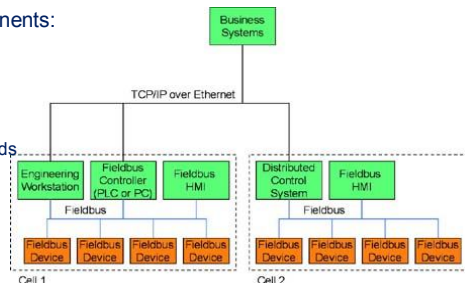
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Requires Supporting Technology?

- YES
- Fieldbus Components:
 - Bus Terminal
 - EtherCAT
 - Fieldbus Box
 - Lightbus
 - PC Fieldbus Cards
 - Switches
 - And more ...

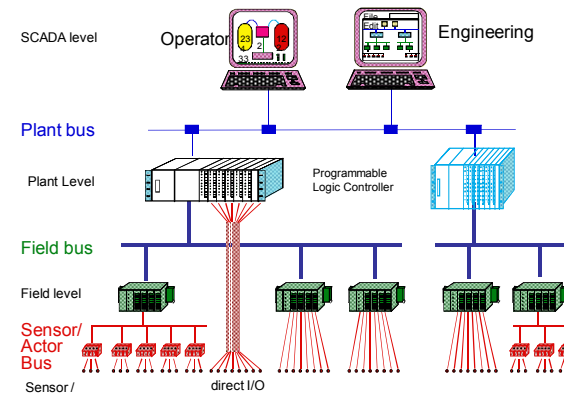


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Location of the field bus in the plant hierarchy



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Expectations

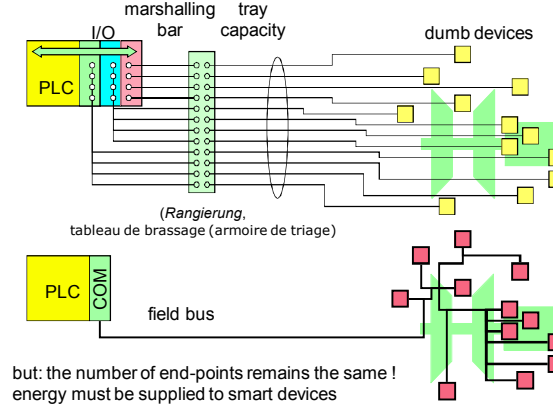
- ✓ Reduce cabling
- ✓ Increased modularity of plant (each object comes with its computer)
- ✓ Easy fault location and maintenance
- ✓ Simplify commissioning (mise en service, IBS = *Inbetriebsetzung*)*
- ✓ Simplify extension and retrofit
- ✓ Large number of off-the-shelf standard products to build "Lego"-control systems
- ✓ Possibility to sell one's own developments (if based on a standard)

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The original idea: save wiring



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Marshalling (Rangierschiene, Barre de rangement)

- The marshalling is the interface between the PLC people and the instrumentation people.
- The fieldbus replaces the marshalling bar or rather moves it piecewise to the process (intelligent concentrator / wiring)

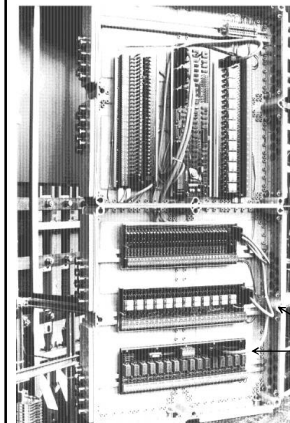


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Distributed peripherals



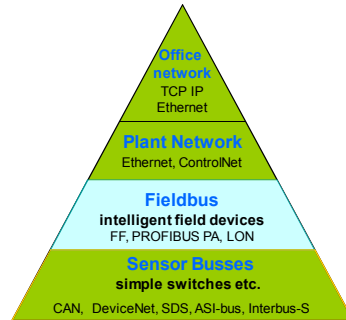
- ✓ Many field busses are just extensions of the PLC's Inputs and Outputs, field devices are data concentrators.
- ✓ Devices are only visible to the PLC that controls them

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Field busses classes



The field bus depends on:
its function in the hierarchy
the distance it should cover
the data density it should gather

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Geographical extension of industrial plants

- 1 km .. 1000 km **Transmission & Distribution**
Control and supervision of large distribution networks:
• water - gas - oil - electricity - ...
- 1 km .. 5 km **Power Generation**
Out of primary energy sources:
• waterfalls - coal - gas - oil - nuclear - solar - ...
- 50 m .. 3 km **Industrial Plants**
Manufacturing and transformation plants:
• cement works - steel works - food silos - printing - paper pulp processing - glass plants - harbors - ...
- 500m .. 2 km **Building Automation**
• energy - air conditioning - fire - intrusion - repair - ...
- 1 m .. 1 km **Manufacturing**
flexible manufacturing cells - robots
- 1 m .. 800 m **Vehicles**
• locomotives - trains - streetcars - trolley buses - vans - buses - cars - airplanes - spacecraft - ...

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Fieldbus over a wide area: example wastewater



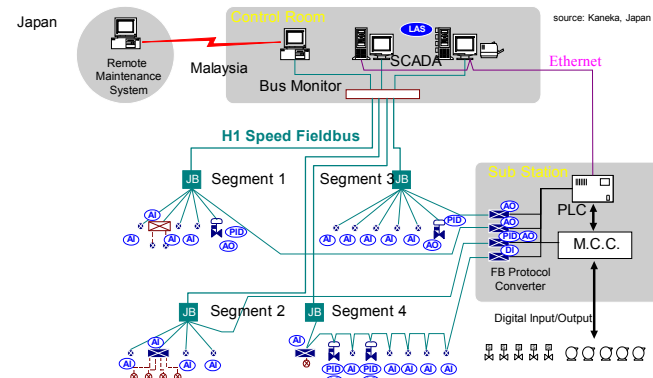
- ✓ Pumps, gates, valves, motors, water level sensors, flow meters, temperature sensors, gas meters (CH_4), generators, ... are spread over an area of several km^2
- ✓ Some parts of the plant have explosive atmosphere.
- ✓ Wiring is traditionally 4..20 mA, resulting in long threads of cable (several 100 km).

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Fieldbus over a wide area: Water treatment plant



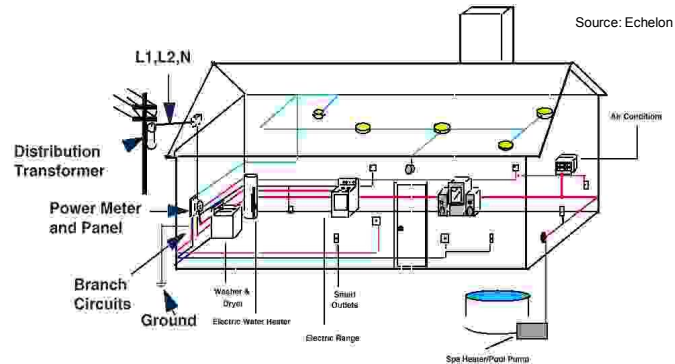
Numerous analog inputs (AI),
low speed (37 kbit/s) segments merged to 1 Mbit/s links.

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Fieldbus application: Building Automation



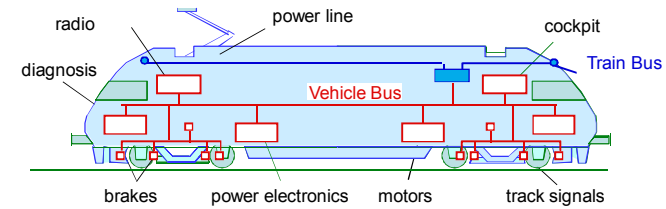
low cost, low data rate (78 kbit/s), may use power lines (10 kbit/s)

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Fieldbus Application: locomotives and drives



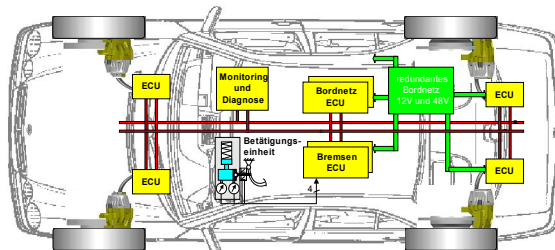
data rate	1.5 Mbit/second
delay	1 ms (16 ms for skip/slip control)
medium	twisted wire pair, optical fibers (EM disturbances)
number of stations	up to 255 programmable stations, 4096 simple I/O
integrity	very high (signaling tasks)
cost	engineering costs dominate

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Fieldbus Application: automobile



- 8 nodes
- 4 electromechanical wheel brakes
- 2 redundant Vehicle Control Unit
- Pedal simulator
- Fault-tolerant 2-voltage on-board power supply
- Diagnostic System

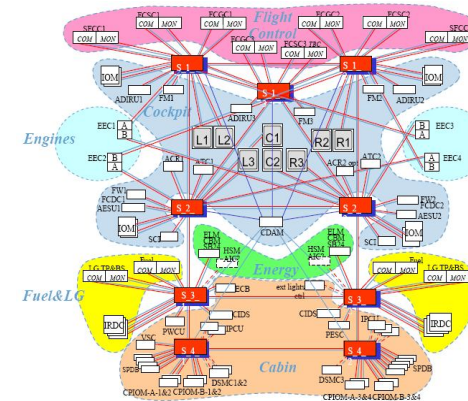
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Application: Avionics (Airbus 380)

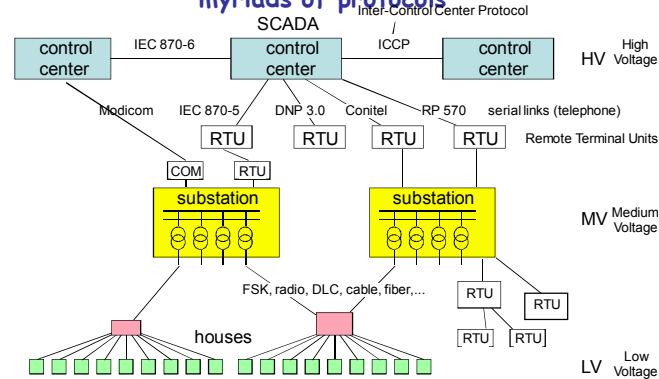


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Networking busses: Electricity Network Control: myriads of protocols



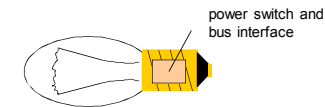
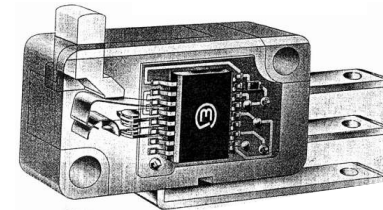
low speed, long distance communication, may use power lines or telephone modems.
Problem: diversity of protocols, data format, semantics...

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The ultimate sensor bus



requires integration of power electronics and communication at very low cost.

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Engineering a fieldbus: consider data density (Example: Power Plants)

Acceleration limiter and prime mover: 1 kbit in 5 ms

Burner Control: 2 kbit in 10 ms

per each 30 m of plant: 200 kbit/s

Fast controllers require at least 16 Mbit/s over distances of 2 m

Data are transmitted from the periphery or from fast controllers to higher level, but slower links to the control level through field busses over distances of 1-2 km.

The control stations gather data at rates of about 200 kbit/s over distances of 30 m.

The control room computers are interconnected by a bus of at least 10 Mbit/s, over distances of several 100 m.

Planning of a field bus requires to estimate the data density per unit of length (or surface) and the requirements in response time and throughput over each link.



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Assessment

- What is a field bus ?
- Which of these qualities are required:
 - 1 Gbit/s operation
 - Frequent reconfiguration
 - Plug and play
 - Bound transmission delay
 - Video streaming
- How does a field bus supports modularity ?
- What is the difference between a sensor bus and a process bus ?
- Which advantages are expected from a field bus ?

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Thank you for your attention!