Fieldbuses and Real time distributed systems

Architectures
Who’s who

- Ethernet
- WorldFIP
- Sercos
- BacNET
- EiBUS
- Interbus
- ControlNet
- Profibus-DP
- TTP
- Profibus-PA
- IEC 61158
- CSMA-BA
- DeviceNet
- CANOpen
- TASE2
- DWF
- Modbus
- CASM
- Sinec
- Profibus-FMS
- ASI
- TTP-A
- TCP/IP
- FDDI
- M-PCCN
- FieldBus Foundation
- EN 50254
- ISO 8802.5
- Batibus
- CiA
- ICCP
- SDS
- ControlNet
- EN 50170
- Hart
- IEC 6375
- CIP
- Sercos 3
- BacNET
- Hart
- TTP
- Profibus-PA
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- CIP
- Sercos 3
- BacNET
Summary

- Applications
- Layered Architectures
- 3-Axis model
- Operational architecture
- Industrial networks history
Position of the fieldbuses

● Complex problem

● Historically
  – Connection of sensors, actuators, controllers
  – Firstly in industrial applications (short distances)

● Development of building automation

● Development of cars automation

● Finally
  – Real time communication systems
  – All real time applications
  – Short distances and wide area networks
Applications of the fieldbuses

- Process control
- Manufacturing applications, machines, ...
- Building applications
- Embedded systems, cars, trains, ...
- Remote monitoring
  - Utilities
  - Telemedicine
  - Transport
Fieldbuses and other networks

- Use of several networks
- Problem of architectures
  - Functional architecture
  - Support architecture
  - Operational architecture
Usual operational architecture

Example

Factory network

Fieldbus1

Fieldbus2
Summary

- Applications
- **Layered Architectures**
- 3-Axis model
- Operational architecture
- Industrial networks history
Layered architectures-1

- Usual architecture in human organisation
- Abstraction of detail through interface definition
- Three examples
  - Input-Output Control Systems
  - Robot Controller
  - Cell Controller
Layered architectures-2

Example 1: IOCS and FMS
Layered architectures-3

Example 1: IOCS and FMS

Read a record (request and result)

FMS

Read a sector (request and result)

IOCS

Start Input-Output

CPU and Disk
Layered architectures-4

Example 2 : Robot control

Go to Point (x, y, z)

Robot controller

Set Point for axis control

Axis 1

Axis 2

Axis 3
Layered architectures-5

Example 3 : Cell Control

Manufacture 100 pieces

Cell controller

Take a piece

Machine1

Robot controller

Machine1
Summary

- Applications
- Layered Architectures
- 3-Axis model
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3-Axis model-1

- 3 axis
  - Hierarchy
  - Physical process
  - Functionalities

- Plans
  - One plan for each function
  - (hierarchy, physical process)

- Traffics
  - Inside a plan
  - Between plans
3-Axis model-2

Representation

- Function
- Physical
- Supervision
- Product tracking
- Control

hierarchy
3-Axis model-3

- “Vertical” flows
  - Request
  - Confirmation
  - Indication
  - Response

Control
- "Vertical" flow
- Client-server model
  - Level I+1 ---> Level I
    - Request
    - Confirmation
  - Level I ---> Level I+1
    - Indication
    - Response
“Vertical” flow

- Language L1
  - Interpreter
  - Language L2

Control
3-Axis model-6

- Functional schema
- Operational schema

The network transmits requests, confirmations, indications, responses
“Vertical” flow
- Time constraints
- Response time
  - Delay between Rq and Cnf
  - Delay between Ind and Rsp
“Horizontal” flow

Exchange of data
3-Axis model-9

- “Horizontal” flow
- Exchange of data
- No service required by the sender to the receiver
- Multicasting generally
- To inform concerned entities in order to provide a global coherence
- Updating of state variables in concerned entities
3-Axis model-10

- **Producer(s) - Consumer(s)**
- **Send**
- **Receive**
- **Message interpretation by the receivers**

With or without acknowledgement
3-Axis model-11

- “Horizontal” flow
- Time constraints
- No time response
- Related to the life time of the state variables
- Life time for the producer
- Validity times for the consumers
- Coherence between all the consumers
Summary

- Applications
- Layered Architectures
- 3-Axis model
- **Operational architecture**
- Industrial networks history
Operational architecture-1

- Result of the mapping of the functional architecture on a support architecture
- Distribution of the functions on sites
- Translation of the functional flows in messages exchanged on the networks
- Existing functions on some sites (constraint)
- Constraints coming from the network
Operational architecture-2

Example

Factory network

Fieldbus1

Fieldbus2
The networks implement
- the vertical flow and
- the horizontal flow

The throughput must be large enough for the functional flows

Necessity for validation

Transformation of different flows into messages
Industrial networks taxonomy

- Cell networks
- Factory networks
- Control room networks
- Fieldbuses
- Sensorbus
- Devicebus
Summary

- Applications
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Fieldbuses-5

- Standardization

1982
- 1st meeting
  FIP

1985
- Development
  CAN
  PROFIBUS
  P-NET

1989
- Tentative choice of international standard

- National standards

- First meeting
  IEC TC 65/SC65C/WG6
Fieldbuses-6

- Standardization

1989 1993 1995 1997 1999

IFG OFC then IFC

ISP

Physical layer IEC 1158-2

Fieldbus Foundation

IEC 1158-3,4,5,6 different votes, appeals, ...

Two headed monster

WorldFIP

EN 50170

EN 50295 ASI
Fieldbuses-7

● Standardization 5

1999

- EN 50170
  6 profiles
- EN 50254
  3 profiles
- EN 50325
  3 profiles

2002

- IEC 61158
  8 profiles
- IEC 62026
  5 profiles
- IEC 61174
  18 profiles
- IEC 61804
  FB
- IEC 61131
  Lges
- Pr EN50391
  EDDL