WISA becomes WSAN
- from proprietary technology to industry standard
WISA becomes WSAN

Outline

- Factory Automation vs. Process Automation
- What is being standardized? In what context?
- WISA-WSAN timeline
- ABB products
- WSAN communication characteristics
Factory Automation (FA) vs. Process Automation (PA)

Different requirements

“Same-Same but Different”
Factory Automation (FA) vs. Process Automation (PA)

Different requirements

In FA, a **plant** is a factory floor.
In PA → e.g. a process plant.

In FA, a **unit** is, say, a robot production cell or a roundtable machine.
In PA → a single process(?)

In FA, a **device** is typically a sensor/actuator or small I/O concentrator/hub.
In PA → e.g. field instrument, valve
Factory Automation wireless challenges

- Reliable Communication
  "Every event is sacred"

- Real-time Performance
  \[\uparrow\]

- Wireless Control!

- High Node Density
  \[Node = \text{device}\]

- Wireless power?
  \[\downarrow\]

- Low Power

- Small size

- Low cost
From WISA to WSAN
What is being standardized?

WISA-COM
Uses the 802.15.1 PHY spec, 2.4 GHz with added custom FDD (frequency-division duplex)
Custom protocol: low latency and high update rate and low power consumption and high node density
Custom coexistence functionality (frequency hopping; freq. whitelisting)
Over-the-air device configuration

WISA-POWER
Large "coils", 120 kHz alternating current
→120 kHz varying magnetic field, 2D
Pickup coils in sensors, 3D
Energy storage in sensors (capacitors)
Low-power custom hardware design

WSAN: Wireless Sensor-Actuator Network

Still ABB proprietary
Related workgroups within PI (PROFIBUS PROFINET International) as per April 2012:

**WSAN - CB/PG11, formerly TC2/WG12:**
Factory Automation - the *integration of sensors and actuators into* PROFIBUS and PROFINET.
Leader: Bernd Kärcher, Festo AG

**Integration HART and WirelessHART - CA/PG1,** formerly a subgroup of TC2/WG12:
Process Automation - the *integration of HART/WHART sensors and actuators into* PROFIBUS and PROFINET.
Leader: Ralf Greiner-Jacob, SIEMENS AG

**Industrial Wireless - CP/PG4, formerly TC2/WG1:**
Factory Automation - how to use WLAN/Bluetooth etc. as *communication carrier for* PROFINET/PROFIBUS, and to *define additions for wireless PROFINET-IO devices.*
Leader: Ralf Greiner-Jacob, SIEMENS AG

See also [http://www.profibus.com/community/working-groups/tcwg-details/](http://www.profibus.com/community/working-groups/tcwg-details/)
**WISA-WSAN timeline 1998-2012**

- **1998**
  - Start
  - Concept ready

- **1999**
  - Demonstrator

- **2000**
  - Prototypes
  - WISA-COM adapted as basis for wireless FA standardization WSAN

- **2001**
  - 1st draft of WSAN spec ready

- **2002**
  - WSAN spec formally reviewed

- **2003**
  - WSAN spec released

- **2004**
  - Low power, hw miniaturization, real-time hw/sw optimization
  - Concept upgrade (freq.hopping, multi-uplink);
    - Production-quality HW / SW / mechanics;
    - Cost & power optimization

- **2005**
  - Additional products: I/O pad, sensor pad

- **2006**
  - Smaller I/O pad

- **2007**
  - Gen 2 of device comms unit

- **2008**
  - Gen. 2 of base station frontend (supports WSAN)

- **2009**
  - Product building block upgrades; standardization

**Legend:**
- Red: Concept and technology demonstration
- Yellow: Low power, hw miniaturization, real-time hw/sw optimization
- Green: Concept upgrade (freq.hopping, multi-uplink);
  - Production-quality HW / SW / mechanics;
  - Cost & power optimization
- Blue: Additional products: I/O pad, sensor pad
WISA-COM vs. WISA-POWER

ABB's product portfolio

Wireless Communication

Wireless I/O-Pads

24 V wired power

Wireless I/O-Module (“Base station”)

Wireless Power Supply

Wireless Proximity Switches

Wireless Sensor Pad

Wireless I/O-Pads

Power Supply

Wireless Power Loops

3 m

3-6 m

3-6 m

Ref. ABB wireless product pages:
http://www.abb.com/product/seitp329/c9c850a941f3612cc12570cb0027bd75.aspx?productLanguage=us&country=NO
ABB's initial WISA product suite; 2004

WISA: Wireless Interface to Sensors and Actuators

Wireless Proximity Switch

1bit binary sensor input (on/off)

Base station antennas

WirelessPower Supply

Standard fieldbus

Base-station (“IO-Module”)

serving up to 120 wireless proximity switches

Wireless Power Loop

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More WISA products from ABB; 2005-2008

- **I/O-Pad, 2005**
  - 8bit binary inputs
  - + 8bit binary I/O
  - 24 V wired power

- **Sensor Pad, 2006**
  - 8bit binary inputs
  - Wireless power

- **I/O-Pad, smaller form factor, 2008**
  - 8bit binary I/O
  - 24 V wired power

I/O means selectable as either input or output. Each output can deliver 500 mA to e.g. on/off actuator.

Base station upgraded to handle a mix of 1bit and 8bit/16bit devices
WISA products in use
- Wireless control in practice

Wireless I/O-pads in a robot cell for the production of AL-motorblocks at KS Aluminium-Technologie AG in Neckarsulm

Wireless proximity switches in a cable winding machine for the production of high voltage sub-sea cables in Karlskrona, Sweden

Wireless I/O-pads in a production cell with robots

Wireless proximity switches in an innovative robot cell (welding application), free of compressed air, at FFT EDAG Produktionssysteme in Fulda

Wireless proximity switches in a packaging machine part for the final packaging of soup bags for Knorr soups at Unilever Germany in Heilbronn

Wireless proximity switches in a pallet handling for the final assembly of motor starters MS116 at ABB STOTZ-KONTAKT in Heidelberg

Video (in Spanish): http://www.youtube.com/watch?v=suuaFZFj0HM

ABB product pages: http://www.abb.com/product/seip329/c9c850a941f3612cc12570cb0027bd75.aspx?productLanguage=us&country=NO
WSAN communication characteristics

**TDMA** (time-division multiple access) and **FDD** (frequency-division duplex)

**Uplink / downlink staggering**

- Time [Double-slots]
- Uplink telegrams from up to 60 or 120 devices on 4 frequencies
- Downlink telegrams from the base station

**WSAN timing on the air**

<table>
<thead>
<tr>
<th>Sensor / actuator telegram (“uplink”)</th>
<th>Double slot telegram</th>
<th>Single slot telegram</th>
<th>Frame = communication cycle time</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>18 bytes = 144 bits</td>
<td>9 bytes = 72 bits</td>
<td>16 Dslots = 2304 µs = 2.304 ms</td>
</tr>
<tr>
<td></td>
<td>...of which user data 80 bits</td>
<td>...of which user data 8 bits</td>
<td>...of which 2 bits reserved for sensor value</td>
</tr>
</tbody>
</table>

| Base station telegram (“downlink”)   | 18 bytes = 144 bits  |                                                        |
|                                      | ...of which user data 64 bits |                                                          |
WSAN communication characteristics

Telegrams – overhead vs. user data (payload)

Sensor/actuator
short telegram
(2 single-slots)

Sensor/actuator
long telegram
(double-slot)

Base station telegram
(double-slot)

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References

ABB wireless product pages:
http://www.abb.com/product/seitp329/c9c850a941f3612cc12570cb0027bd75.aspx?productLanguage=us&country=NO

PROFIBUS/PROFINET International (PI) overview of standardization working-groups:
http://www.profibus.com/community/working-groups/tcwg-details/

*Same-Same but Different* is an Asian-English phrase, mainly used in Thailand, but also the title of a 2009 German movie set in Cambodia
http://www.imdb.com/title/tt1368443/plotsummary

Power and productivity for a better world™
Requirements – High Node Density

50 - 300 nodes / cell

Node density 0.2 - 1 / m³

<table>
<thead>
<tr>
<th>Use Case</th>
<th>Dimension (W x L x H) in m</th>
<th>Volume in m³</th>
<th>Cells per factory hall</th>
<th>IO points per cell</th>
<th>assumed wireless nodes</th>
<th>IO point density in cell (1/ m³)</th>
<th>Wireless node density in cell (1/m³)</th>
<th>Factory hall size* in m³</th>
<th>Wireless node density over factory hall (1/m³)</th>
<th>IO density in factory hall (1/m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot Manufacturing Cell</td>
<td>8 x 8 x 2.5</td>
<td>160</td>
<td>40</td>
<td>400</td>
<td>40</td>
<td>3</td>
<td>0.25</td>
<td>12800</td>
<td>0.13</td>
<td>1.25</td>
</tr>
<tr>
<td>Roundtable Production Cell</td>
<td>8 x 7 x 2.5</td>
<td>140</td>
<td>50</td>
<td>300</td>
<td>100</td>
<td>2</td>
<td>0.71</td>
<td>14000</td>
<td>0.36</td>
<td>1.07</td>
</tr>
</tbody>
</table>

Robot Manufacturing Cell

Machine cycle 10 s

Roundtable Production Cell

Machine cycle 1 s
**Roundtable Production Cell**

1 production step per second

  - min. 2 events / second (typ.)

100 wireless nodes (typ. per cell)

  - 720 000 telegrams per hour*

  - 17 Mio. telegrams per day (3 shift production)

  - **5 * 10e9 telegrams per year** (neglecting weekends)

**Error rate has to be << 10e-9**

  - for not maintaining the designed real time limit (e.g. 15ms)

  - In real environments!

* Assumes digital sensors. Concentrator IO nodes would have typ. 8 times more events!!
Cell Size and Power Configurations

3 m
1 m
1 m
3 m
3 m
3 m
3 m
1 m
4,5 m
4,5 m
4,5 m
4,5 m
6 m
6 m
6 m
6 m

3 x 3 x 3 m³
4 Primary loops
2 Power supplies

3 x 3 x 4.5 m³
5 Primary loops
3 Power supplies

3 x 6 x 6 m³
6 Primary loops
6 Power supplies

Source: Keynote speech, ETFA 2008, by Jan Erik Frey, ABB