Wireless and Sensing Solutions for Improved Industrial Efficiency

Task A: Development of a Pervasive Wireless Industrial Sensing Infrastructure

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Wireless Sensing Solutions

Task A: Wireless Network for Industrial Applications
- Robust industrial wireless infrastructure
- High data security
- Lowest total cost of ownership
- Low power requirements and extended battery life
- Enhanced availability and coexisting with other RF systems

Task B: PHASED Gas Composition MicroAnalyzer
- MEMS based micro gas chromatograph
- Real-Time, on-/by-line measurement of process streams
- High-Speed, sub-second analysis time
- 20-50-Stage, sub-second pre-concentration
- NeSSI-Compatible Microanalytics
- Low-Power requirements
- Affordable
Industrial Wireless Sensing

• Need:
  - A low cost, reliable and secure wireless sensor network for industrial applications that offers significantly improved monitoring and control, reduced energy consumption, and reduced environmental emissions.

• Core Technology:
  - Highly robust radio communications
  - Scalable latency-controlled multi-hop mesh network
  - Secure wireless communications with convenient key management
  - Very long battery life

Wireless sensors will become the obvious choice for industrial process monitoring and control
Industrial Wireless Sensing

• Novel Elements
  - Robust radio design supporting 5+ year battery lifetime
  - Space / time / frequency diversity for interference management
  - Low power cryptographic authentication and privacy
  - Latency controlled message delivery

• Key Project Deliverables
  - Voice of the customer interview data
  - Industrial wireless requirements documents
  - Radio performance test results and trade-off assessments
  - Unique system architecture to meet requirements
  - Operational factory deployment testing results for analytical sensors and wireless network

Design, development, and field testing of a robust, scalable, secure wireless network at two industrial plant sites
Barriers and Pathways

Key challenges:
- Industrial wireless devices can not have batteries recharged as with traditional mobile devices
- Unreliable (intermittent) communications, as in conventional RF devices, is unacceptable
- Existing systems suffer significant message latency or packet loss problems on scale-up
- Lack of user interface for security key deployment on wireless sensor devices.
- A standard industrial sensing solution that meets customer requirements.

Elements of the solution:
- Extensive voice-of-the-customer assessment to determine critical unmet needs.
- Develop Industrial wireless requirements specification
- Assess and test existing wireless alternatives
- Design an innovative network architecture addressing identified industrial wireless requirements:
  - Low power wireless sensors
  - Low power / convenient cryptography
  - Robust wireless architecture
- Drive consensus in market through WINA and SP100 standardization process

Continued investment and participation of DOE and industrial partners will overcome the key challenges
Wireless Value Proposition to End User

- **Up to 10:1 reduction in capital expenditure**
  - No signal wiring or conduit for new points
  - No marshalling area space or termination assemblies
  - No additional I/O cabling into automation system
  - No I&E documentation for wiring and termination interconnect
- **Modest reduction in operational expenditure**
  - No budget for wiring and conduit maintenance
  - No spares for termination assemblies
- **Easy addition of more sensors**
  - Richer understanding of plant processes
  - Additional coverage when primary sensors fail
  - Better process diagnostics
  - Suitable for temporary placement during unit troubleshooting

- **Usable where wired connections are infeasible**
  - due to long distance (e.g., piers and quays, pump houses)
  - due to large common-mode voltage differences (e.g., motors, tank farms)
  - over water or non-owned obstructions (e.g., roadways)
  - on vibrating, rotating, or moving machinery (e.g., large motors, fans, cranes)
  - great height: stacks, towers, tanks (e.g., for monitoring emissions)

Eliminating wiring costs opens the opportunity for pervasive sensing
Industrial Wireless System Key Requirements

1. Reliable communications
   - Robust to single point failures
   - Resistant to interference / jamming

2. End to end latency control
   <50% of reporting period.

3. Capacity and scalability
   1000 Leaf Nodes, 100 Infrastructure nodes

4. Success rate
   95% of latency-controlled packets delivered on time

5. Localized faults

6. Global solution / standard

7. Co-existence with 802.11b/g

8. Multiple periodic reporting rates
   250ms to 1 hour or more.

9. Data QoS classes
   1. Latency controled 2. High throughput
      3. Immediate 4. Low Importance

10. Security
    Privacy, Integrity, Authentication, Key management.

11. Diagnostics / alarm reporting

12. Power cycle recovery

13. Battery life
    > 3 years

A solution addressing **all** requirements is needed for industry acceptance.
Important Metrics

• **Wireless Networks**
  - Ability to scale system up to 1000’s of wireless devices in a single factory area with high sensor reporting rates.
  - Controlled message latency of less than one half the sample time
  - Reliable (> 95%) delivery of latency controlled messages
  - Highly secure wireless communications with simple key deployment
  - Coexistence with common wireless networks supporting mobile devices (e.g. WiFi)

• **Wireless Sensors**
  - Battery life in excess of 5 years for untethered devices
  - Low installed cost (less than 1/10th that of wired sensors)

• **Wireless Standards**
  - Establishment of ISA committee (SP100) with strong participation from DOE sponsored contractors

Program results will significantly exceed performance of existing wireless systems and set the benchmark for the future
Accomplishments (1 of 5): Radio Development and Testing

• Established industrial wireless requirements through voice-of-the-
customer interviews
• Completed prototypes of wireless leaf node radios
• Evaluated performance of FHSS and DSSS wireless technologies
  against industrial process requirements

FHSS 20dBm radio

802.15.4 20dBm radio
Accomplishments (2 of 5): Wireless Interference Test System

Interference Source 1 - Transmitter

Interference Source 2 - Receiver

Coexistence
Accomplishments (3 of 5): IEEE 802.11g Interference Testing

Impact of 802.11g

FHSS is less sensitive to interference from 802.11g
Accomplishments (4 of 5): Wireless Network Architecture

- Designed a robust wireless network architecture
- Completed initial infrastructure node design
- Supported formation of ISA SP100.

Designed scalable, secure, reliable wireless network supporting latency control and low-power sensors.
Accomplishments (5 of 5): Wireless Network Performance Testing

- Lessons Learned
  - Latency constraints and high periodic update rates affect the wireless network capacity drastically
  - Existing commercial networks tested could only handle 1% of the network capacity

![Graph showing Reliability and Latency Requirements for Mesh Networks 1 and 2]

- Number of Leaf nodes reporting at 1 sec (or packets per second (pps) at gateway)
Continuation after ITP-Sponsored Project / Commercialization plan

- Continue to support establishment of industrial wireless standards
- Aggressively introduce and promote industrial wireless sensors and networks
- Support collaborators and partners to enable effective industrial wireless solutions and corresponding wireless market development.
- Pursue tight integration with industrial control systems
- Develop advanced wireless network support tools and device installation tools

Honeywell is a leading supplier of industrial wireless systems and will aggressively support industry development.
Current Industrial Wireless Sensing System

Wireless Transmitters

Bi-directional Wireless Link
900 Mhz FHSS

Base Radio

Modbus or
4-20mA
interface

Wireless Management Toolkit
RS232 interface

First Generation Product
“XYR 5000”
Next Project Steps and Future Milestones

- Complete network design to meet industrial requirements and lab demonstration of network with sensors by 4Q 2005
- Integrate sensors, wireless network, and control system into field-able prototype by 4Q 2006
- Install and complete performance testing in two industrial plants by 2Q 2007

Network design & prototype
Sensor & control system integration
Field testing

2005 | 2006 | 2007

Project success dependent on deployment and performance testing of a scalable, secure, and reliable wireless network at two plant sites
Commercial/Technical Risks Remaining

• Technical Risks
  - Maintenance of batteries remains a major concern; alternate power and power management required
  - Scalability to large (>10K sensors in a network) network remains a technology hurdle
  - Secure communication with easy key management remains a risk

• Commercial Risks
  - Continuing confusion in marketplace over expectations from wireless networks results in low adoption rates
  - Lack of standards to unify market space
  - Aggressive marketing of poorly developed wireless networks can damage the industry perception of value

Growth of the industry and benefits derived depend on systematic development and introduction of solutions that address key requirements of reliability, scalability, security, and battery life
Energy Savings

- How will energy be saved?
  - Improved industrial process control leading to improved product quality and fewer process upsets
  - Monitoring of steam traps in industrial processes
  - Faster introduction of new sensor and analytical technology
  - Condition-based diagnostics and maintenance resulting in fewer unexpected shutdowns
  - Ability to deploy temporary sensing to solve in efficient control problems

- How much energy will be saved?

Estimated Energy Savings