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Ubiquitous Wireless Smart Sensing & Control

Pumps & Pipes JSC:
Uniquely Houston

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Challenge Overview:

Need new technologies to reliably and safely have humans interact within sensored environments (integrated user interfaces, physical and cognitive augmentation, training, and human-systems integration tools). Areas of focus include: radio frequency identification (RFID), motion tracking, wireless communication, wearable computing, adaptive training and decision support systems, and tele-operations. **The challenge is developing effective, low cost/mass/volume/power integrated monitoring systems to assess and control system, environmental, and operator health;** and accurately determining and controlling the physical, chemical, and biological environments of the areas and associated environmental control systems.

Challenge Update:

- follow-up session held on May 16, 2013
- limited uptake so far from Pumps & Pipes partners
    - challenge going into “hibernation” for time being
- work continues on infusing industrial processing control standards into NASA applications:
    - Integrated Avionics, Power, and Software (iPAS) testbed
    - satellite test facilities (inc., ECLSS lab)
- work continues on adapting RFID technology to sensing
- partners still sought with
    - problems requiring wireless solutions
    - wireless solutions to problems

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Backup

Benefits and Drawbacks Wireless Sensing

- **Benefits:**
  - removing wires/connectors reduces launch weight
  - sensors can be easily added, relocated during vehicle lifetime
  - sensors can be placed where running wires prohibitive
  - sensors can easily be relocated between vehicles (e.g., supply module to habitation module)
  - radio frequency (RF) links are single-fault tolerant (at the receiver)

- **Drawbacks:**
  - reliable RF comm. difficult with low-power radios due to:
    - co-existence with other wireless systems
    - time-varying multi-path interference
    - RF noise
  - truly wireless comm. requires self-contained power supplies

Families of Wireless Sensing

- **Passive:**
  - Radio Frequency Identification (RFID):
  - most commonly used for inventory management
  - uses harvested power to transmit its data
  - two main variants:
    - EPCglobal (e.g., Wal-Mart inventory management)
    - Surface Acoustic Wave (SAW)

- **Active:**
  - battery (or scavenged/stored) power enables transmission
  - much greater bandwidth at the expense of power consumption
  - many variants:
    - IEEE 802.15.4, ZigBee, ISA100.11a, WirelessHART
    - Ultra Wideband (e.g., IEEE 802.15.4a)
    - Bluetooth
    - IEEE 802.11 (e.g., Wi-Fi)

Problem Area: Maximizing Time Between Servicing

- **Must maximize ease of installation, maintenance:**
  - ideally “lick and stick”
  - cannot require significant crew time to replace batteries
  - sensor lifetime must be significant fraction of vehicle lifetime
- **Must develop full-function (e.g., routing) networks capable of deep sleeping**
  - allows increasing reliance on scavenged power
- **Must investigate pushing completely passive (e.g., RFID) techniques into sensing roles**
  - battery assisted (EPCglobal)
  - completely passive (SAW, EPCglobal)

Problem Area: Coping with Flood of Data

- **Ease of installation encourages proliferation of sensing:**
  - more producers of data encourages more consumers of data
  - publish/subscribe middleware techniques must support ad-hoc addition of both

- **Data generation may exceed long-haul link capacity:**
  - lower bandwidth and/or unreliable ground links may not accommodate all new data
  - delay/disruption tolerant networking (DTN) techniques must allow for prioritized transmission of backlogged data

- **Scalable wireless solutions must be chosen:**
  - protocols should allow steady addition of radios up to bandwidth limits
  - "infrastructure" approaches should use common networks for diverse sensing tasks

Problem Area: Overcoming Institutional Bias

- **Wireless viewed as unreliable for critical applications**
  - RF interference main issue
  - users must become comfortable with interference mitigation techniques (must continue improve)

- **Spectrum sharing viewed unfavorably**
  - dedicated bandwidth will not support wide proliferation of wireless
  - users must become comfortable with co-existence techniques (must continue improve)

- **Users reluctant to adopt low-bandwidth solutions**
  - distributed compression greatly reduces bandwidth requirements, increases system lifetimes
  - users must be convinced that processing at sensor can still fulfill system requirements