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
Contact

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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