Hybrid Spread-Spectrum Sensor Telemetry, Tracking, & Information System

Project No. S06-011

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Spread Spectrum is Vastly Superior to Traditional RF Communication Methods

- Three basic forms: direct-sequence (DS), frequency hopping (FH), and time hopping (TH).
- Can be resistant to interference and multipath effects.
- May permit multiple-access channels and ranging (location) functions.
- Can provide good security (encryption) at modest cost.
- Five special frequency bands have been allocated by the U.S. FCC for license-free use (some also worldwide).

RF Communications Technology is Vital for Mission Success

- Spread-Spectrum Signaling
  - LPI/LPD/Prioritized Hybrid (DS/FH/TH)
  - Ultrawideband(shaped)
- Random Networks
  - Tactical communications
  - Remote sensor telemetry
- Smart Devices
  - Low power consumption
  - Infrequent transmissions
  - Autoconfiguring nets

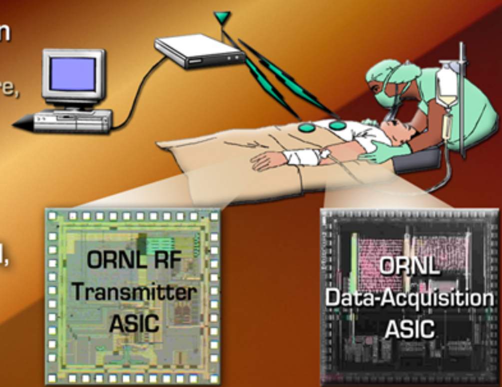
The Problem

- Existing spread-spectrum wireless protocols (e.g., Wi-Fi, Bluetooth, and ZigBee), intended for consumer and office applications, were designed for low cost and highest possible data rates, not robustness and security!
- Disadvantages:
  - Multipath-induced data degradation.
  - High sensitivity to interference from other proximal wireless devices in the same frequency band.
  - Significant interference caused to other nearby wireless devices in the same frequency band.
  - Relatively poor data security.
  - Poor multiple-access properties.
  - Low power efficiency (relatively poor battery lives).
  - Very poor jamming resistance (not designed for hostile RF environments).

Typical Medical Telesensor Device Operation

Wireless monitoring of vital signs permits better care, faster recoveries, lower costs!

HSS: Improved data reliability, lower RFI, better confidentiality



Container Tracking for Ports

Typical Industrial Wireless Environment

Conventional techniques cannot deal with the extreme multipath and multiple-access requirements; HSS can!

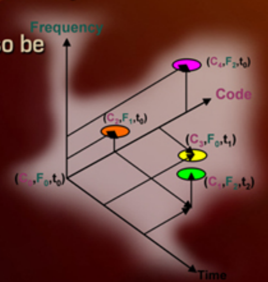
Typical Harsh Wireless Environments

ORNL's Solution: Hybrid Spread Spectrum

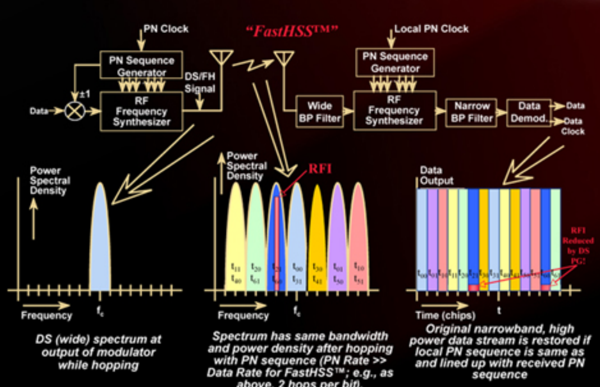
- Novel, adaptive technique (U.S. Patent 7,092,440; 2 others pending).
- HSS: a synergistic, programmable combination of DS, FH, and TH.
- Advantages:
  - Adaptive Hybrid Spread-Spectrum (HSS) modulation format combines DSSS and frequency/time hopping in a multi-dimensional, orthogonal signaling scheme.
  - Capable of excellent LPI, LPD & security properties (programmable).
  - Adaptive, robust protocol for high QoS applications.
  - Can be operated in burst mode for very low power drain.
  - Superior resistance to multipath and jamming (high process gain).
  - Easily deployed with modern chip technology.
  - Compliant with existing government rules for license-free ISM bands.
  - Ideally implemented via modern FPGA-based electronics and software-defined radio (SDR) techniques.

HSS is a Multidimensional Signal

- HSS can be defined in 3 axes (code, frequency, and time). Each dimension is orthogonal with the others. Permissible signal spaces along an axis may also be ~ orthogonal.
  - Codes
  - Frequencies
  - Time slots
- Easily adaptable: exploits many degrees of freedom to meet system requirements.

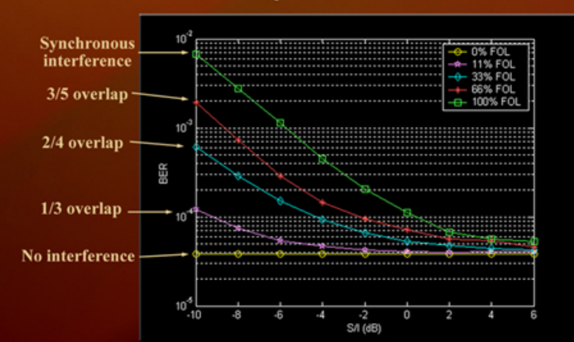


Fast Hybrid Spread-Spectrum (DS/FFH)

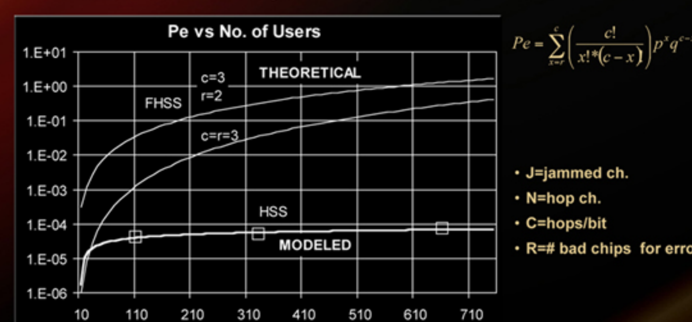


The Goal: Demonstrate the Performance Superiority of HSS

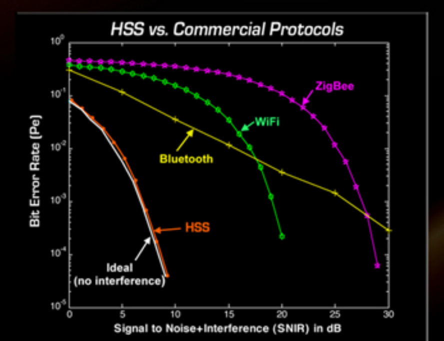
HSS Multiple-Access Performance



Bit-Error Probability vs. No. of Users



Performance Comparison



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