Wireless Sensor Network for Aircraft Health Monitoring

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Technologies presented here are patent pending. For more details, please send emails to haowei.bai@honeywell.com
Ad-Hoc Sensor Network

Characteristics
- Each node generates independent data.
- Power is the driving constraint.
- Source-destination pairs are chosen randomly.
- Topology is dynamic.
- Routing could be multihop.
- Need to allocate resource dynamically (rate, power, bandwidth, routes, etc).

Design Challenges
- Limitations of the Wireless Network
  - packet loss due to transmission errors
  - frequent disconnections/partitions
  - limited communication bandwidth
  - Broadcast nature of the communications
- Limitations Imposed by Mobility
  - dynamically changing topologies/routes
  - lack of mobility awareness by system/applications
- Limitations of the Mobile Computer
  - short battery lifetime

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### Our Proposed Solutions

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<td><strong>Limitations of the Wireless Network</strong></td>
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<td>Packet loss due to transmission errors</td>
<td>Error control and anti-interference (FHSS, OFDM)</td>
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<td>Limited communication bandwidth</td>
<td>Using high data rate RF technology, e.g., IEEE 802.11a/b</td>
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<td>Broadcast nature of the communications</td>
<td>MAC protocol in Ad Hoc Networks</td>
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<td><strong>Limitations Imposed by Mobility</strong></td>
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<td>Dynamically changing topologies/routes</td>
<td>Ad Hoc routing</td>
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<td>Frequent disconnections/partitions</td>
<td>MAC, Network addressing/membership for Ad Hoc network</td>
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<td>Lack of mobility awareness by system/applications</td>
<td>Node positioning</td>
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<td><strong>Limitations of the Mobile Computer</strong></td>
<td>Short battery lifetime</td>
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**Communication protocol stack**

- **Power-aware routing for Ad Hoc**: Reactive routing protocol, which starts to create routes when requested.
- **Low-power MAC**: sleep and wake-up scheme, which allows a node power itself down when it is neither sending nor receiving.
- **Node positioning**: put node’s location (coordinates) as part of its address.

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Node Architecture of Ad Hoc Sensor Networks

• Concept Description
Standard Power & Communications Module

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Honeywell Wireless Sensor Network in Harsh Env.

Voice of the Customer
- High temperature capability.
- Less weight, improved reliability by eliminating wiring and wiring harnesses issues.
- More sensors onboard for predictive monitoring:
  - Installation cost savings (wiring costs)
  - Wireless sensors in places where wires are impossible (e.g., rotating shaft)
  - Network easily upgraded / modified

Honeywell Technologies
- SOI chip for up to 250C temperature capability.
- Single-chip wireless sensor node.
- Robust FHSS communication.
- Self-powered wireless sensor.
- Power-aware communication protocols.
- Node positioning capability and protocol.
- Node ID and authentication for comm security.
- Sensor network for harsh environment.

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Custom Single-chip Radio

- Honeywell Low Cost Single-chip RF Transceiver (GROW Chip)

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ASIC Details

Chip Size: 4.5mm x 4.5mm

- PA (Power Amp)
- DIFFERENTIAL BASEBAND FILTER
- LNA (Low Noise Amp)
- I/Q MIXERS
- VCO
- DEMOD
- PLL
- CRYSTAL OSC
- DIGITAL AND SPI

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Honeywell Single-chip Radio Main Features

**RF System**
- Fully integrated 418-928 MHz transceiver.
- Binary FSK Modulation.
- Lowest cost fully integrated RF solution requiring minimal external components.
- Programmable data rates up to 56 kbps.
- Programmable modulation frequency up to 2MHz.
- Adjustable Tx power levels from –20dBm up to +4dBm.
- Adjustable on-chip filters.
- Integrated PLL/VCO capable of 2kHz programmable increments.
- Integrated direct conversion receiver with –100dBm sensitivity.
- Low noise figure of Rx path (NF_{RXSYS} < 10dB).
- Capable of frequency agile communications.
- Received Strength Signal Indicator (RSSI) output for link quality indicator.
- Compatible with North American FCC Title 47 Part 15.
- Compatible with European ETS-300-220
- Compatible with United Kingdom MPT 1329/1340

**Digital Interface and Functions**
- Serial Peripheral Interface for configuration, Tx/Rx data transfer, program Tx power level, and PLL frequency.
- Digital Tx and Rx section with 64 byte FIFO
- 64 bit correlator in Rx
- Encoder and Decoder

**CMOS Technology**
- Low-power consumption (25 ma)
- < 1.5 μA standby current
- Single supply operation (3.3 - 2.4 volts).
- Mature 0.35μm CMOS fabrication geometry.

**Cost Target**
- Changed RF architectures to meet $5 final assembled Xcvr cost goal.
- Plastic Quad Flat Pack is initial package

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Honeywell’s Position

- Honeywell already produces RF on a chip.
- Honeywell already produces secure communications.
- SOI is mature and proven, with additional functions and components being added from the DeepTrek DOE program.
- Wireless networks will allow easy addition of sensors for vehicle health management.
- Reduced weight by eliminating electrical harness.

Can bring Honeywell expertise in industrial wireless, mil communications and high temperature / high reliability electronics to bear on wireless sensors.

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