

## TABLE OF CONTENTS

1	Executive Summary
2	Short Range Radios - Introduction
3	Short Range Radio Systems
3.1	802.11
3.1.1	Older Versions of 802.11
3.1.2	802.11n
3.1.3	Pre-Standard Products
3.1.4	Security
3.1.5	Future
3.2	Bluetooth
3.2.1	Bluetooth Applications
3.2.2	Spectrum
3.2.3	Security
3.2.4	Piconet
3.2.5	Standard Versions
3.3	UWB
3.3.1	UWB Introduction
3.3.2	UWB Standardization
3.3.3	The WiMedia Alliance
3.3.4	CableFree
3.3.5	Cwave
3.3.6	Regulatory Issues
3.4	ZigBee
3.4.1	Introduction
3.4.2	The IEEE 802.15.4 Radio
3.4.3	The IEEE 802.15.4 MAC Layer
3.4.4	Applications
3.5	6LoWPAN
3.5.1	6LoWPAN Technical Details
3.5.2	6LoWPAN Applications
3.5.2.1	Industrial monitoring
3.5.2.2	Structural Monitoring
3.5.2.3	Healthcare
3.5.2.4	Connected Home
3.5.2.5	Vehicle Telematics
3.5.2.6	Agricultural Monitoring
3.5.3	Summary
3.6	RFID
3.6.1	Passive tags
3.6.2	Active tags
3.6.3	Semi-active tags
3.6.4	RFID Tag Operating Frequencies
3.6.4.1	UHF Tags
3.6.4.2	HF Tags
3.6.4.3	LF Tags
3.6.5	RFID Tag Security
3.6.6	RFID Advantages
3.6.7	But why slow adoption...

- 3.6.8 Future
  - 3.7 Wibree
    - 3.7.1 Wibree Basics
    - 3.7.2 Applications
      - 3.7.2.1 Sports
      - 3.7.2.2 Health
      - 3.7.2.3 Home
      - 3.7.2.4 Office
      - 3.7.2.5 Automotive
      - 3.7.2.6 Watch
    - 3.7.3 Implementation options
  - 3.8 Wireless USB
    - 3.8.1 Wireless USB Basics
    - 3.8.2 Certified Wireless USB
    - 3.8.3 Other wireless USB systems
    - 3.8.4 Competition by other wireless systems
  - 3.9 Near Field Communication
    - 3.9.1 NFC Basics
    - 3.9.2 NFC Standards
    - 3.9.3 NFC Applications
  - 3.10 HiperLAN
  - 3.11 Wireless HD
- 4 Conclusions
- 4.1 Technical comparison
  - 4.2 Future prospects
    - 4.2.1 802.11
    - 4.2.2 Bluetooth
    - 4.2.3 ZigBee
    - 4.2.4 Wibree
    - 4.2.5 Wireless USB
    - 4.2.6 6LowPAN
    - 4.2.7 RFID
    - 4.2.8 NFC
    - 4.2.9 Wireless HD
  - 4.3 Trends in short-range radios
    - 4.3.1 Hype
    - 4.3.2 Standards Development
    - 4.3.3 Pre-standard products
    - 4.3.4 Security and privacy
    - 4.3.5 Proprietary systems
- 5 Wireless Sensor Networks
- 5.1 WSN Introduction
  - 5.2 WSN Architecture
    - 5.2.1 Structured Networks
    - 5.2.2 Unstructured Networks
  - 5.3 Sensor Radio Technologies
  - 5.4 WSN Protocols
    - 5.4.1 BACnet
    - 5.4.2 X-10
    - 5.4.3 CAN

- 5.4.4 KNX
- 5.4.5 INSTEON
- 5.4.6 Z-Wave
- 5.4.7 EnOcean
- 5.4.8 LonWorks
- 5.4.9 Modbus
- 5.4.10 HART
- 5.5 Sensor Types
  - 5.5.1 Thermal Sensors
    - 5.5.1.1 Thermo-mechanical sensors
    - 5.5.1.2 Thermo-resistive sensors
    - 5.5.1.3 Thermo-electric sensors
    - 5.5.1.4 Resonant Temperature sensors
  - 5.5.2 Electromagnetic sensors
    - 5.5.2.1 Ohmmeters
    - 5.5.2.2 Galvanometers
    - 5.5.2.3 Ammeters
    - 5.5.2.4 Electrical Voltage Sensors
    - 5.5.2.5 Electrical Power Sensors
    - 5.5.2.6 Magnetism Sensors
  - 5.5.3 Mechanical Sensors
    - 5.5.3.1 Piezoresistive Sensors
    - 5.5.3.2 Piezoelectric Sensors
    - 5.5.3.3 Capacitive Sensors
    - 5.5.3.4 Inductive Sensors
  - 5.5.4 Chemical sensors
    - 5.5.4.1 Chemiresistor Sensors
    - 5.5.4.2 Chemical And Biological Sensors
    - 5.5.4.3 Metal-Oxide Gas Sensors
  - 5.5.5 Biosensors
  - 5.5.6 Optical sensors
    - 5.5.6.1 Photodetectors
    - 5.5.6.2 Infrared sensors
    - 5.5.6.3 Fiberoptic sensors
    - 5.5.6.4 Interferometers
    - 5.5.6.5 Photoelectric
    - 5.5.6.6 Photoconductive
  - 5.5.7 Radiation sensors
    - 5.5.7.1 Ionization Chambers
    - 5.5.7.2 Proportional Counter
    - 5.5.7.3 Geiger Counter
    - 5.5.7.4 Scintillation Detectors
    - 5.5.7.5 Solid State Nuclear Radiation Sensors
  - 5.5.8 Acoustic sensors
  - 5.5.9 Motion sensors
  - 5.5.10 Orientation sensors
- 5.6 Spectrum
  - 5.6.1 ISM Bands
  - 5.6.2 Spectrum Crowding
  - 5.6.3 Solving the 2.4 GHz Band Interference Problem

- 5.7 Power
  - 5.7.1 Power saving
  - 5.7.2 More efficient batteries
  - 5.7.3 Energy Harvesting
    - 5.7.3.1 Piezoelectric energy harvesting
    - 5.7.3.2 Thermoelectrics
    - 5.7.3.3 Biological fuel cells
    - 5.7.3.4 Pyroelectric energy harvesting
    - 5.7.3.5 Electrostatic energy harvesting
    - 5.7.3.6 Solar
    - 5.7.3.7 Other harvesting technologies
    - 5.7.3.8 Selected Experimental Energy Harvesting Systems
  - 5.7.4 Fuel Cells
  - 5.7.5 Wireless energy transfer
- 5.8 WSN Applications
  - 5.8.1 Military Applications
    - 5.8.1.1 Tracking of troops or military vehicles
    - 5.8.1.2 Intelligent Mine Field
  - 5.8.2 Smart Buildings
    - 5.8.2.1 Power Monitoring
  - 5.8.3 Surveillance and observation
    - 5.8.3.1 Airport Security
    - 5.8.3.2 Wildlife Observation
    - 5.8.3.3 Virtual Fences
  - 5.8.4 Environmental Monitoring
    - 5.8.4.1 Glacier Monitoring
    - 5.8.4.2 Ocean Monitoring
    - 5.8.4.3 Agricultural Monitoring
  - 5.8.5 Healthcare
    - 5.8.5.1 Vital Signs Monitoring
  - 5.8.6 Tracking
    - 5.8.6.1 Cold Chain Tracking
    - 5.8.6.2 Avalanche Rescue
- 5.9 WSN Deployment and Management
  - 5.9.1 Proposed WSN Management Standards
  - 5.9.2 WSN Cost
  - 5.9.3 WSN Deployment Problems
  - 5.9.4 Security
    - 5.9.4.1 Tampering of Data
    - 5.9.4.2 Eavesdropping
    - 5.9.4.3 Detecting the Presence of the Network
    - 5.9.4.4 Physically Destroying the Sensor Nodes
    - 5.9.4.5 Spamming
- 5.10 Market Forecast
- 5.11 Sensor Suppliers
- 5.12 Commercially Available Wireless Sensor Systems
  - 5.12.1 Accsense
  - 5.12.2 Accutech
  - 5.12.3 ArchRock
  - 5.12.4 Banner Engineering

- 5.12.5 Coronis
- 5.12.6 Crossbow Technology
- 5.12.7 MeshNetics
- 5.12.8 Microstrain
- 5.12.9 National Instruments
- 5.12.10 Sentilla
- 5.12.11 Techkor Instrumentation
- 5.12.12 Others
- 5.13 Conclusions

ANNEX A. A List of Selected IEEE 802 Working Groups

ANNEX B. Spectrum Usage

ANNEX C. Manufacturers of WiFi Certified 802.11n Draft 2.0 Products (as of August 2008)

ABBREVIATIONS