Wireless Sensor Network (WSN) Applied to Logistics: Opportunities and Challenges

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Cubic Global Tracking Solutions
21 March 2012
Intermodal Container Tracking
Commercial and Military Conveyance

Next Generation Wireless Communications (NGWC) for Logistics Applications

NGWC Enabled Continuous Asset Visibility

Active RFID Chokepoint Visibility

GAP GAP GAP GAP GAP GAP GAP GAP GAP

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Cubic Global Tracking Solutions

21 March 2011
Real-time Asset Tracking: JLOTS

Joint Logistics Over-the-Shore (JLOTS)
Yard Management: Camp Arifjan

Yard Management/Process Analysis
- Near Real-Time, continuous visibility of equipment moving through the process
- Actionable information on dwell times within process supports better resource management
- Provides significant Return on Investment (ROI) and cost avoidance
Moffett Field Deployment
Dynamic mobile mesh. Every node is a router, end-node, but also optionally a gateway:
  - True ad-hoc networking
  - Worldwide compliance with local regulations
  - Redundant gateways
  - Highly reliable and secure wireless link
    - Link level security
    - Emission control (no unwanted RF pollution)
    - Very high congestion tolerance
  - 99.9% message delivery guarantee even in dynamic environment

Location tracking capability
  - Regulatory, e.g. FCC, HERO, FAA, etc.

Scalability
  - Decentralized mesh
  - Node address space is virtually unlimited
  - Dynamic routing
  - Hundreds of hops

Years of battery life
  - Regardless of environmental conditions
  - UN regulations
  - Guaranteed minimum battery life

Global Logistics Requirements

- Location tracking capability
- Regulatory, e.g. FCC, HERO, FAA, etc.
- Scalability
- Decentralized mesh
- Node address space is virtually unlimited
- Dynamic routing
- Hundreds of hops
- Years of battery life
- Regardless of environmental conditions
- UN regulations
- Guaranteed minimum battery life
## Required All-inclusive Feature Set

<table>
<thead>
<tr>
<th>Required: Not always</th>
<th>Smart Energy</th>
<th>Smart Home</th>
<th>Industrial Controls</th>
<th>Health Care</th>
<th>Smart Agriculture</th>
<th>Logistics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low latency / high throughput</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
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<tr>
<td>Low power (&lt;1mW)</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Reliability (&gt;99.9%)</td>
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<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Security (FIPS140)</td>
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<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>Scalability (10K nodes, 250 hops)</td>
<td>✔</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
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</tr>
<tr>
<td>Ad-hoc/dynamic</td>
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<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>Zero-configuration Worldwide</td>
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<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>High contention threshold (&gt;1000)</td>
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<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
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<tr>
<td>Predictable power consumption</td>
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<td>❌</td>
<td>❌</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
</tbody>
</table>

*mist™*
Real-Time Asset Visibility

Active RFID infrastructure

CGTS Mesh infrastructure

Reader / Gateway

Backup Reader / Gateway

Mechanicsburg, PA - Navy AIT Office
February 2, 2010

1,800 Feet
Longer Active RFID range exponentially increases congestion
Shorter Active RFID range inadvertently decreases coverage
Mesh nodes can reduce range to reduce local congestion, but still provide coverage through multihop
GPS Viability in Logistics
Redundant Gateways Requirements
Scalability Beyond 10K is Required

Unique devices, by gateway, by day

Nodes on the single network tested!

mist™
mist™ Mesh Network

- Years of battery life in active use for every node-router
- Up to 1000/1 node to gateway ratio is recommended. 6500 node mesh has been tested
- 2 levels of security in the networking stack. FIPS140-2/3 Level 2
- True Ad-Hoc joining in seconds
- Redundant gateways
- Any-to-any routing
- Self-healing, zero-configuration
- Guaranteed minimum battery life
- EUI-64 device address
- 99.9% message delivery reliability for unacknowledged messages
- Up to 250 hops is supported by network
- Congestion - 4000 tested
- Optional node binding within ad-hoc environment
Remember WSN Challenges 2010?

- Standards are emerging, but are systems truly interoperable?
- More than 10,000 nodes in a system is rarely feasible.
- In dense modes, do they form hubs (i.e., busy nodes)? Take out the main hubs and you bring down the whole network. No longer self-healing.
- Nodes are expensive “gas guzzlers” with batteries often going flat—desperate need for energy harvesting for 90% of potential.
- Genuine business cases and application experience lacking—still early days.
Logistics Reflects the Dynamic World

• Majority of things get manufactured, installed, moved, replaced, lost, broken, used, etc. Very few things are static for years
• Geographical scale of networks and congestion are unpredictable, so solutions have to account for that now
• Power consumption must be predictable. No use case should make batteries bleed 10 times faster than “nominal”
• Virtually any node should be able to be a gateway when needed, providing powerful gateway redundancy
• Address space of >1 trillion requires EUI-64, IPv6
• Security and privacy cannot be compromised
WSN in Internet of Things

within 100 years ???

• 10 Billion people
• 1 Trillion connected things (100 per person)
Asset Tracking Devices Cost Considerations

- Individual barcode labels  0.1 – 10 cents
- Passive RFID  10 – 35 cents
- Active RFID $10 – 100
- WSN nodes  $50 – 300
- Cellular/GPS trackers  $100 – 300
- Satellite/GPS trackers  $500 – 3,000
# IoT Cost Considerations

<table>
<thead>
<tr>
<th>“Cost” of a “Thing”</th>
<th>“Cost” of “Internet”</th>
<th>Percentage of Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10,000</td>
<td>$100</td>
<td>1%</td>
</tr>
<tr>
<td>$1,000</td>
<td>$10</td>
<td>1%</td>
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<td>$10</td>
<td>10c</td>
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- How many things cost, or can produce profits/losses greater than $1,000?
- How many things can afford expensive communication?

In five years?

- Current prices of WSN nodes

In 50 years?

A pen might never talk to a notebook.
WSN Technical Challenges beyond 2012

- Ubiquitous worldwide connectivity between variety of WSN “long distance / international calls” (IPSO might have answers)
- WSN Public Key Infrastructure “mobile network registration”
- Any-to-any multihop connectivity inside single and adjacent WSN “mobile D2D”
- Redundant gateways “smooth mobile handoff”
- IoT address space of 1 trillion within 50 years (IPv6, IMEI, EUI-64)
- WSN and Smartphone/tablet convergence
WSN Business Challenges beyond 2012

- Lack of WSN infrastructure. Who is going to build IoT infrastructure, how, and who will pay for it?
- How fast can WSN node prices go down, but make business sense to producers?
- Will complimentary technologies have breakthroughs and when? batteries, power harvesters, ultra low power sensors, displays, etc.
- What are the positions of the governments and lawmakers?
- How to balance security with mass adoption?
Enabling the Internet of Things

Enable New Knowledge

Predictive maintenance

Energy Saving (I2E)

Improve Productivity

Intelligent Building

Defnece

Enhance Safety & Security

High-Confidence Transport & assets tracking

Smart Home

Food & H20 Quality

Healthcare

www.ipso-alliance.org
IPSO Alliance – Enabling the Internet of Things

About IPSO:
The IPSO Alliance is the leading organization promoting the use of Internet Protocol (IP) for smart object communications for use in energy, consumer, healthcare and industrial applications.

Vision:
Providing the foundation for a network that will allow any sensor-enabled physical object to communicate to another as individuals do over the Internet.

Value Proposition:
- Create awareness of available and developing technology with IP for Smart Objects
- Coordinate marketing efforts to complement the standard work of the IETF
- Support, organize and market interoperability events
Why IPv6?

- Huge Address Space
  - $2^{128}$ Addresses (667 quadrillion addresses per mm$^2$ of earth’s surface)
  - Every single device can have its own unique address
- Stateless Address Autoconfiguration
  - DHCP servers not required
- No need for Network Address Translation (NAT)
  - No NAT configuration
  - No port translation
Benefits of IPv6

● Unique IP addresses to connect EVERYTHING
● Nodes can easily “phone home”
● Use existing tools, knowledge, protocols
● Use existing infrastructure (no gateways/translators)
● Interoperability (Internet and Devices)
Thank you!

Questions?