

A Proposal for IEEE P1451.5, Standard for a Smart Transducer Interface for Sensors and Actuators - Wireless Communication Protocols and Transducer Electronic Data Sheets (TEDS) Formats

Submission Title: [Clarification of Motorola's Proposal for the IEEE 1451.5 Wireless Smart Sensor Standard]

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Re: [Call for Proposals; Doc. <related doc #'s>]

Abstract: [Clarification and additional information regarding Motorola's proposal]

Purpose: [Response to the Wireless Sensor Working Group Chair's Call for Proposals]

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Clarification of Motorola's Proposal for the IEEE 1451.5 Wireless Smart Sensor Standard

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Updated Information

- On 12 May 802.15.4 received final IEEE approval
- On 27 May Motorola announced 1st customer sampling of RF IC's conforming to a draft (16) of the standard, will demo 03 June in Berlin at the ZigBee™ Alliance Open House in Berlin. Standard-compliant engineering samples available in November http://www.motorola.com/mediacenter/news/detail/0,1958,2743_2228_23,00.html
- New cellular-based Wireless Data Service announced (long-range backhaul)

<http://www.computerworld.com/mobiletopics/mobile/story/0,10801,81505,00.html>

GM Offers Wireless Options to Fleet Buyers

May 26, 2003

By Bob Brewin

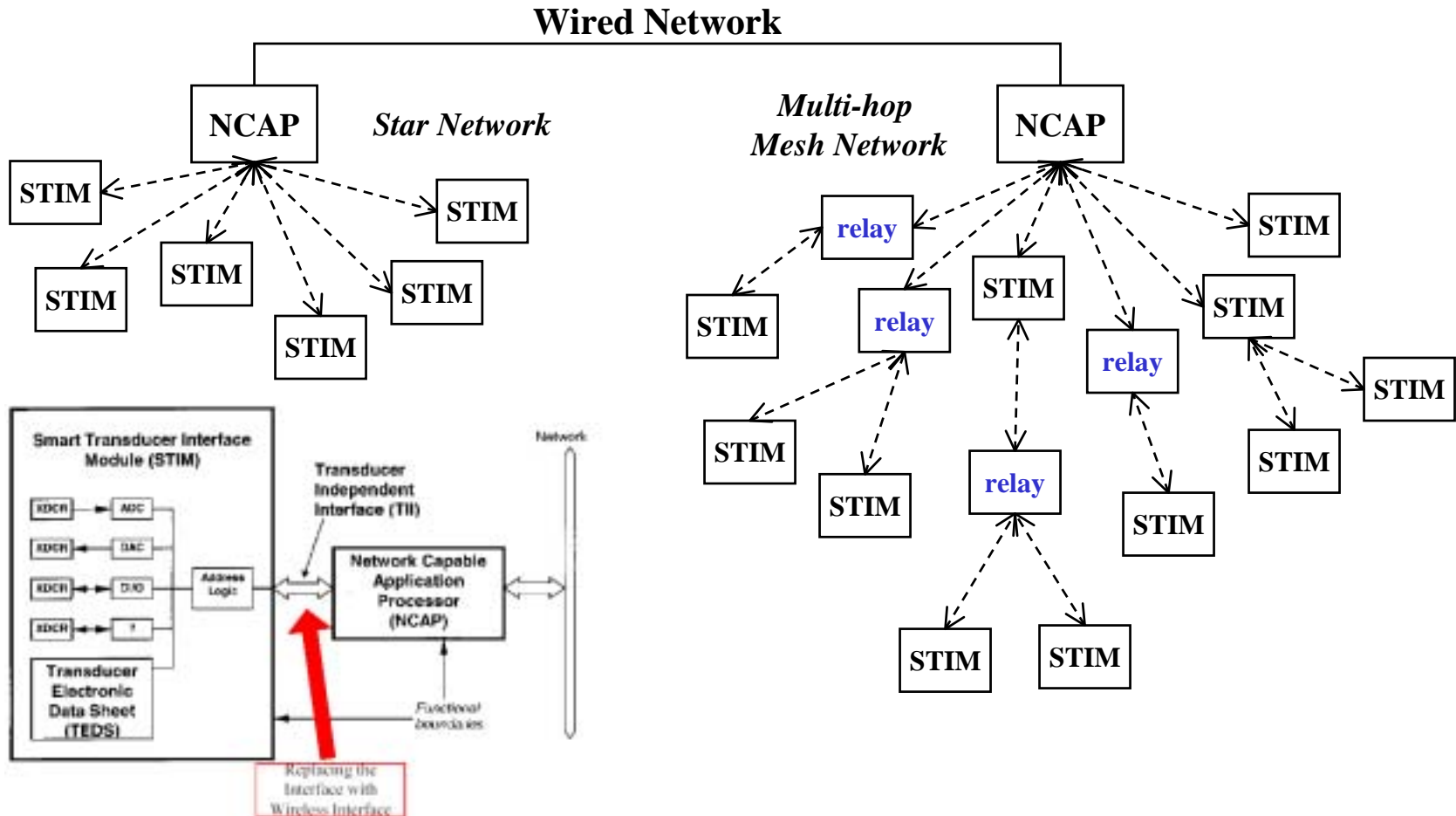
General Motors Corp. said it plans to offer corporate buyers of its pickup trucks and vans a packaged wireless data and fleet-tracking system based on Gearworks Inc. software and Nextel Communications Inc. data phones. ... plumbing and HVAC contractors are seen as the likely purchasers.

Using the [GPS-enabled] Java-based phones, which offer data speeds between 20Kbit/sec and 40Kbit/sec, dispatchers and service workers in the field will be able to exchange simple text-based messages. The GM service is free for a year, Hull said. After that, fleet owners can continue using the service under a plan with monthly fees of \$34 per phone for Gearworks support and \$32.99 per phone for Nextel data services.



A Revision to WHAT is Standardized in our proposal

- We are now persuaded that NCAP (or NCAP-lite) functionality is NOT required in every node of a wireless multi-hop network.



1451.0

- **Motorola believes that a 1451.0 specification structured to allow multiple wired & wireless interfaces between NCAP & STIMs is in the best interest of the 1451 family.**
- **As always, the devil is in the details.**
- **Beyond a minimal light-weight TEDS spec, what is really required?**

A Clarification on the Issue of Link Range (single-hop)

In our 1st presentation, the single-hop Link Range for 802.15.4 was quoted as being “up to 10m (indoor), 30m (outdoor)”.

This is a WORST-CASE scenario assuming:

- 2.45 GHz band specs - 868/915 MHz RX has better sensitivity (lower data rate) and 7-8 dB advantage in propagation loss and will therefore have somewhat longer link range.)

HOWEVER.... 802.15.4 is really only short link range by CHOICE

- Default configuration was optimized for cost & energy consumption desired in the significant majority of applications
- High-performance implementations are NOT PROHIBITED

Motorola still believes primary need for “long range” is for backhaul from a remote sensor cluster, and that we should not burden all transceivers with cost & current drain required for such a link.

802.15.4 - 2.4 GHz Range w/PA

Assumptions

General:

Lossless Isotropic Antenna

Sensitivity: -90 dBm

(System NF: 17 dB)

Calculate path loss from 1λ distance

Ideal LOS:

Path Exponent =2.0

Outdoor:

Antenna height: 1 to 10m

Ideal LOS to distance of antenna height, then

Path Exponent = 3.0

Indoor:

Path Exponent = 3.5

STANDARD CONFIGURATION

IDEAL LOS: 350m

OUTDOOR: 50m to 107m

INDOOR: 10m

+10 dBm EXTERNAL PA

IDEAL LOS: 1,100m

OUTDOOR: 107m to 230m

INDOOR: 20m

+20 dBm EXTERNAL PA

IDEAL LOS: 3,500m

OUTDOOR: 230m to 500m

INDOOR: 40m

Use of an external LNA is also possible to improve RX Sensitivity

A 7 dB System NF in either frequency band (+10 dB improvement) is readily achieved for modest cost & current drain.

802.15.4 - 868/915 MHz Range w/ PA & LNA

- Adding a PA (+20 to +200 mW_{DC}) would increase TX to +10, +20 dBm.
- Adding an LNA (+20 mW_{DC}) could improve RX from -92 to -102 dBm.

Any 915 MHz 802.15.4 radio will have a similar Link Range as any other 915 MHz radio having comparable TX power, RX sensitivity, Antenna(s), and Modulation.

How Similar are the Modulations?

Low-Rate PHY Comparison

DSSS Specification	Axonn	802.15.4 868/915 MHz	802.15.4-2450 MHz
Frequency (MHz)	902-928	868.0-868.6 // 902-928	2403-2480
# Channels	8	1 // 10	16
Symbol Rate (ksym/s)	19.4 or 58.2/116	20 // 40	62.5
PN Sequence Length	63	15	32
Chip Rate (kchips/s)	1220	300 // 600	2000
Symbols	Binary	Binary Orthogonal	16-ary Orthogonal
Carrier Modulation	OOK/BPSK, (BPSK only)	BPSK	O-QPSK
Data Rate (kb/s)	19.4 or 58.2/116	20 // 40	250
RX Sensitivity (dBm)	~ -108 dBm or 103/100	(< -92 std.) -102	(-90) -100
Max. Freq. Tol. (\pm ppm)	40	40	40
RX Synch. Preamble	92 bits 4742 μ s	32 bits 1600 // 800 μ s	32 bits 128 μ s
RX-TX, TX-RX turnaround		600 // 300 μ s (12 sym)	192 μ s (12 sym)
Max Packet Length (bytes) (ms)	256 105.6, or 35.2/17.7	128 51.2 // 25.6	128 4.1
TX Power (mW)	100	(>0.5 std) 100	(>0.5 std) 100
Baseline Current Drain Baseline Power (mW) Long Range Power (mW)	~165 mA @ 5.2-8.0V 858-1360	? ?+220	~30 mA @ 2.0-3.6 V {60-108 @ 1 mW TX} 280-328 w/PA & LNA

Multi-path Mitigation

Typical Indoor Environments*

Home	<50 ns
Office	~100 ns
Manufacturing Floor	200-300 ns

* IEEE 802.11 Handbook, Table 8-1, p.163

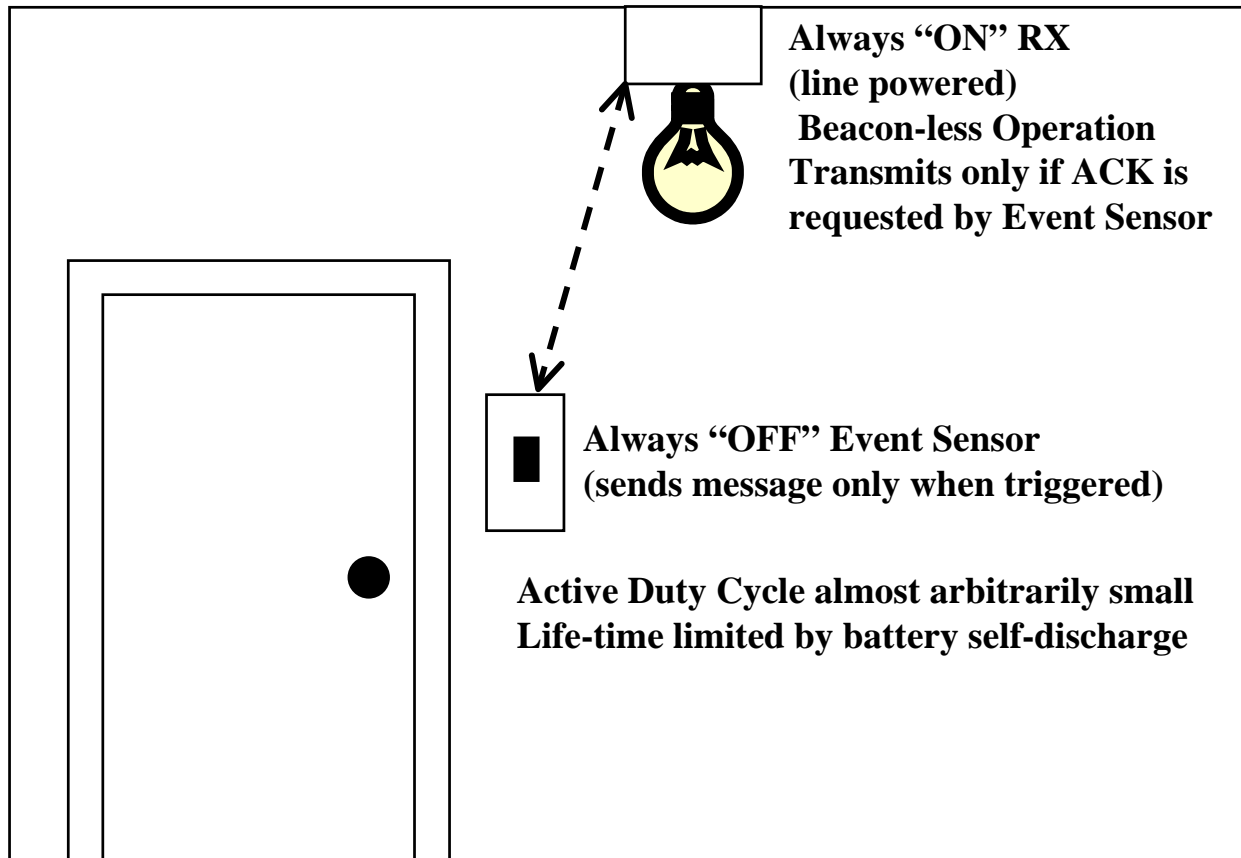
- In order to significantly improve multi-path performance in these environments, one would need to spread a single channel across substantially the entire 915 MHz band (25 MHz) and increase p-n code length to ~512-1024 chips.
- This would very significantly increase receiver die sizes & current drain.
- A multi-hop mesh network is another solution to a multi-path problem between any two individual node.

About Transmit-Only Operation

Motorola believes that Receiver-less nodes are unattractive for a “Smart Sensor” standard because:

- 1. Awkward to support TEDS**
without a RX, it would seem that one must either:
 - a. Periodically transmit TEDS over the air (a BW & energy consumption penalty)**
 - b. Manually trigger TEDS transmission when a sensor is added to the system (not robust to NCAP replacement)**
 - c. Manually provision TEDS into RX base station (expensive)**
- 2. Collision management (multiple-sends, just in case) can potentially consume more energy than having a receiver to:**
 - a. perform CSMA-CA (avoiding most collisions) and listen for a short ACK message rather than automatically broadcasting multiple times.**
 - b. using a Guaranteed Time Slot with a beacon frame (small networks, or networks where only a few “TX-only” like devices are required)**
Especially for “long range” designs where TX power is relatively high (50-100 mW).
- 3. “Smart” should mean able to remotely adjust sensor behavior (sampling interval, time constant or average, etc.) at need, or upon command.**
- 4. Quasi-1way operation possible in 2-way protocols like 802.15.4**

quasi-TX only scenario



Security

ZigBee™ Alliance is developing security policies for multi-hop mesh networks.

Will probably use:

Elliptic Curve Cryptography

May also support certificates.

International Utility

- **We believe IEEE Standards should have International utility**
- **802.15.4**
 - **2.45 GHz has virtually global coverage**
 - **868/915 covers both Europe (ETSI) & USA (FCC)**

Intellectual Property Rights (IPR)

- **No “essential” IPR has been declared by any company for 802.15.4**
- **IPR in ZigBee Network proposals has been offered Royalty-Free.**

In Addition to a Low Rate Standard (in 2 RF bands)

- **Motorola believes that at least one protocol capable of high-rate, low-latency data should be supported**
- **There are multiple choices. How many? How to choose?**
 - 802.11x (WiFi) – no support for isochronous data; 11b is most widely deployed and chip set prices are plummeting; 11a would provide a presence in a 3rd frequency band (5.2/5.7 GHz)
 - 802.15.3 (WiMedia) – isochronous support for A/V
 - 802.15.1 (Bluetooth) – isochronous support for voice
 - Future – TG802.15.3a is UWB, talk of forming a SG for 15.4a, etc.,.
- **Motorola suggests a “slash” designation, e.g.:**
 - 1451.5/ZigBee-2450,
 - 1451.5/ZigBee-868/915
 - 1451.5/WiFi-11x
 - 1451.5/WiMedia
 - 1451.5/Bluetooth