



# Overview of 802.15 Projects

November 30, 2009

Bob Heile

Chair, IEEE 802.15

Chairman, ZigBee Alliance

Co-Chair IEEE P2030 Smartgrid Communications Task Force

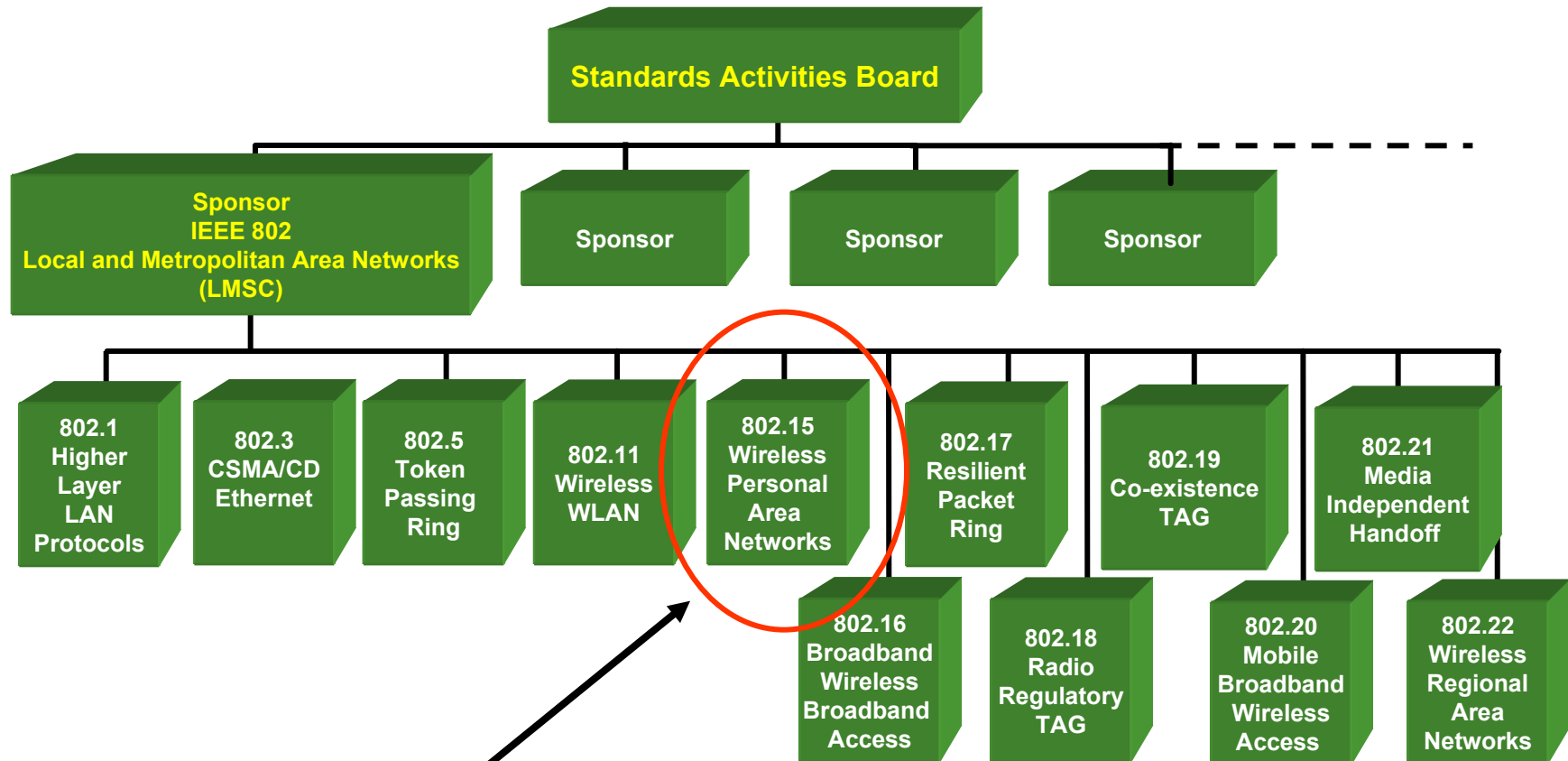
# Disclaimer...

“At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that his or her views should be considered the personal views of that individual rather than the formal position, explanation, or interpretation of the IEEE.”

IEEE-SA Standards Board Operation Manual (subclause 5.9.3)

# IEEE 802 Organization

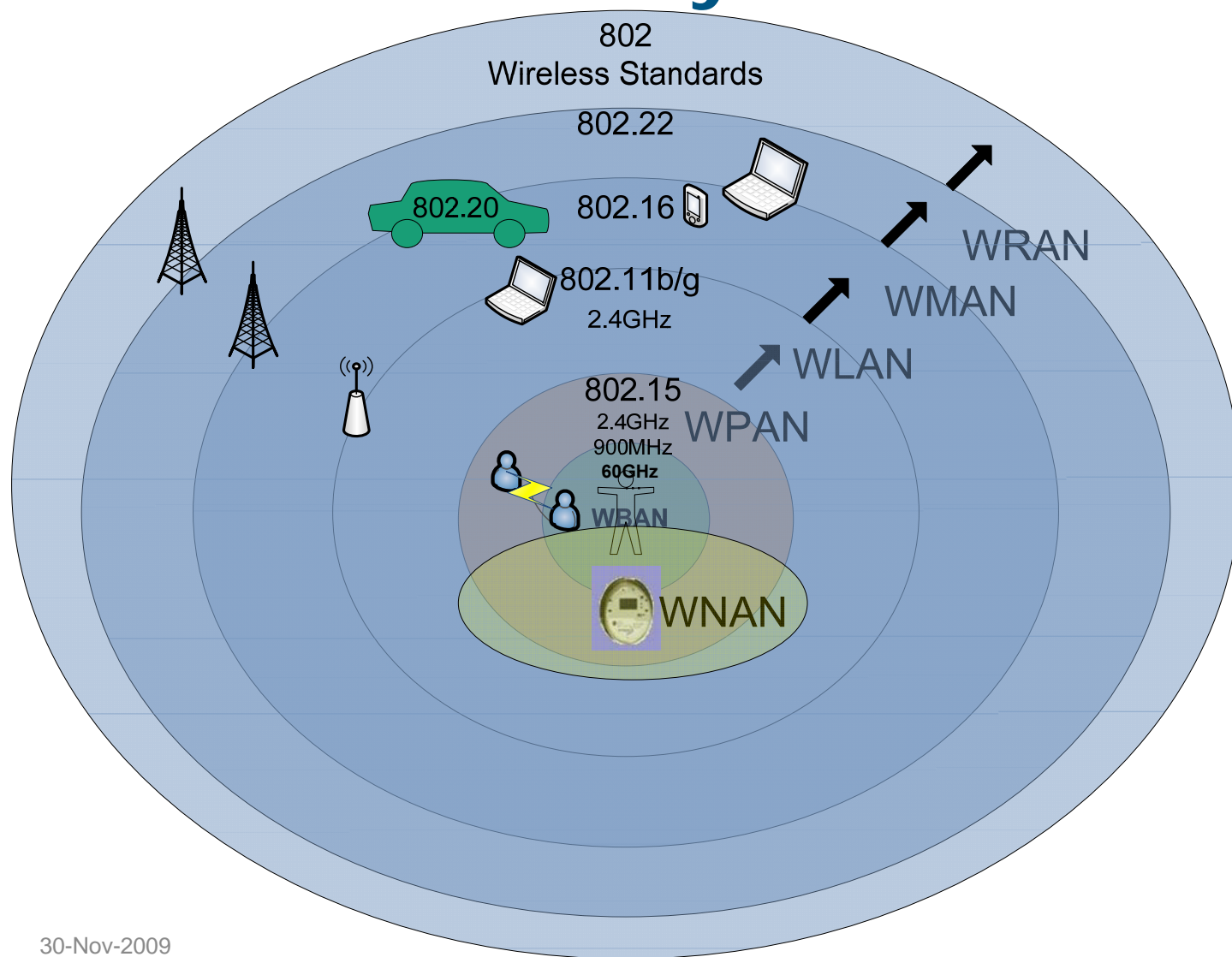
## IEEE Standards Association



Voting Members ~230

[www.ieee802.org/15](http://www.ieee802.org/15)

# 802 Wireless Ecosystem



# 802.15 Historical Retrospective

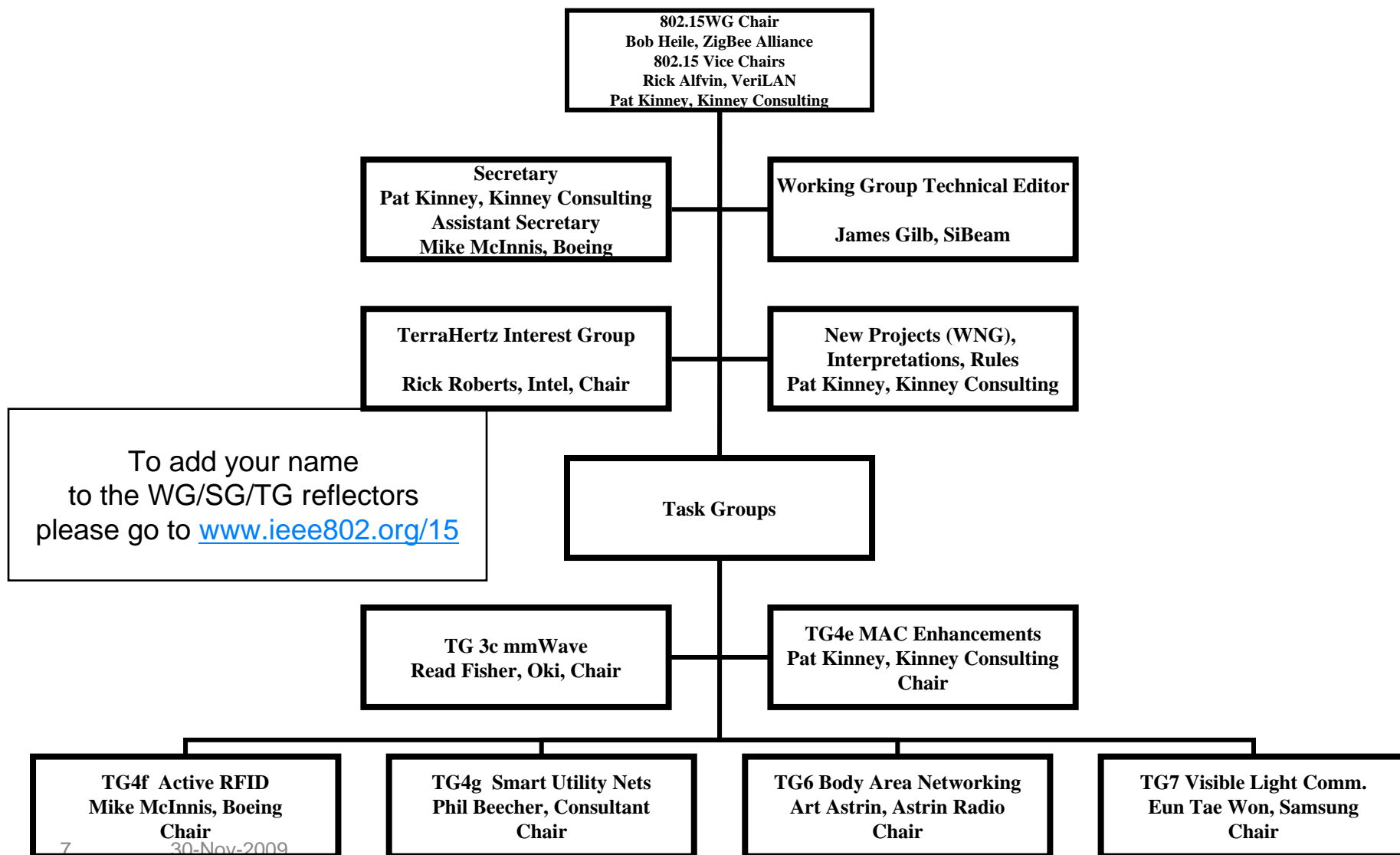


- In 1997, Fedex and several other companies were looking to have standards suitable for interconnecting devices typically worn
- In March 1998, an 802.11 Study Group was formed to address the issue
- In March 1999, 802.15 was created to develop standards for Wireless Personal Area Networks

# 802.15 Scope and Purpose

- Initial activities focused on wearable devices hence “personal area networks”
- Activities have proven to be much more diverse and varied
  - Data rates from 2kbps to 2gbs
  - Ranges from meters to kilometers
  - Frequencies from 400MHz to 800THz
  - Predominantly non TCP/IP applications
- Focus is on “specialty”, typically short range, communications. If it is wireless and not a LAN, MAN, RAN, or WAN, odds are its 802.15
- Only 802 Working Group with multiple MACs

# 802.15 Organization Chart



# 802.15 Completed Projects

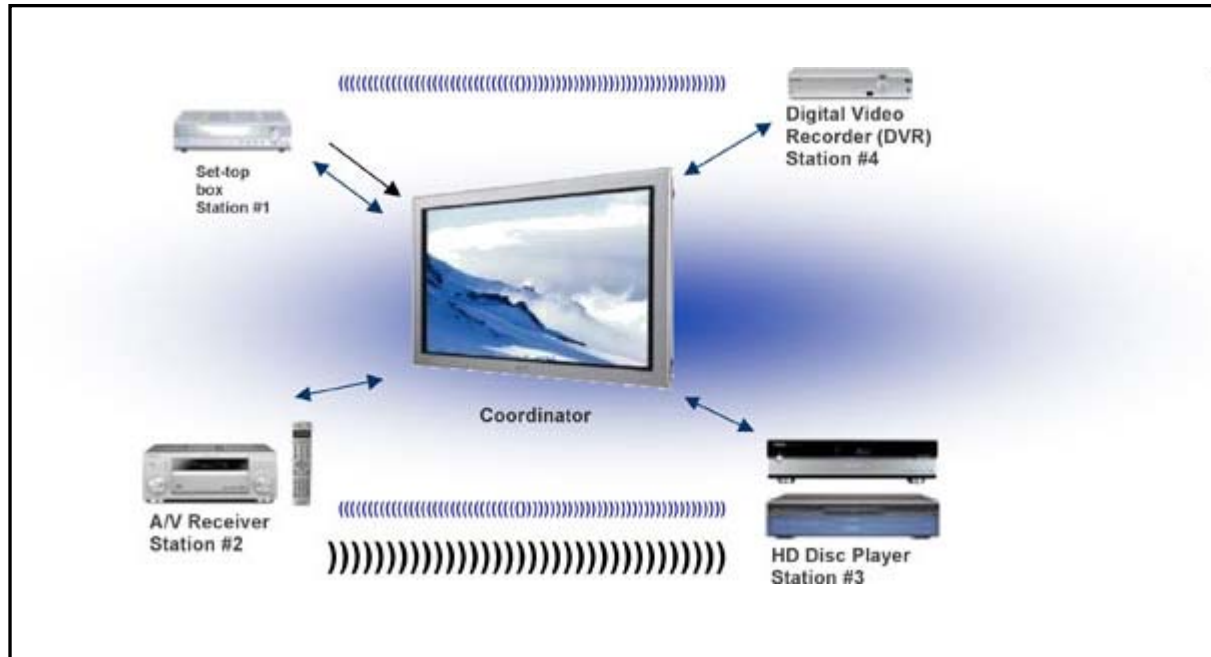
- 802.15.1-Bluetooth
- 802.15.2-Coexistence Recommended Practice
- 802.15.3-High Rate (55 Mbps) Multimedia WPAN
- 802.15.3c-High Rate (>1Gbps) mmWave 15.3 PHY
- 802.15.4-Low Rate (250kbps) WPAN
- 802.15.4a-Higher data rate 15.4 PHY
- 802.15.4c-Sub 1 GHz 15.4 PHY for China
- 802.15.4d-Sub 1 GHz 15.4 PHY for Japan
- 802.15.5-Mesh Networking Recommended Practice



# 802.15 Active Projects

- ▣ 802.15.4e- 15.4 MAC Enhancements
- ▣ 802.15.4f- 15.4 PHY for Active
- ▣ 802.15.4g- 15.4 PHY for Smart Utility Networks
- ▣ 802.15.6- Body Area Networking
- ▣ 802.15.7- Visible Light Communications

# 60 GHz WPAN 802.15.3c



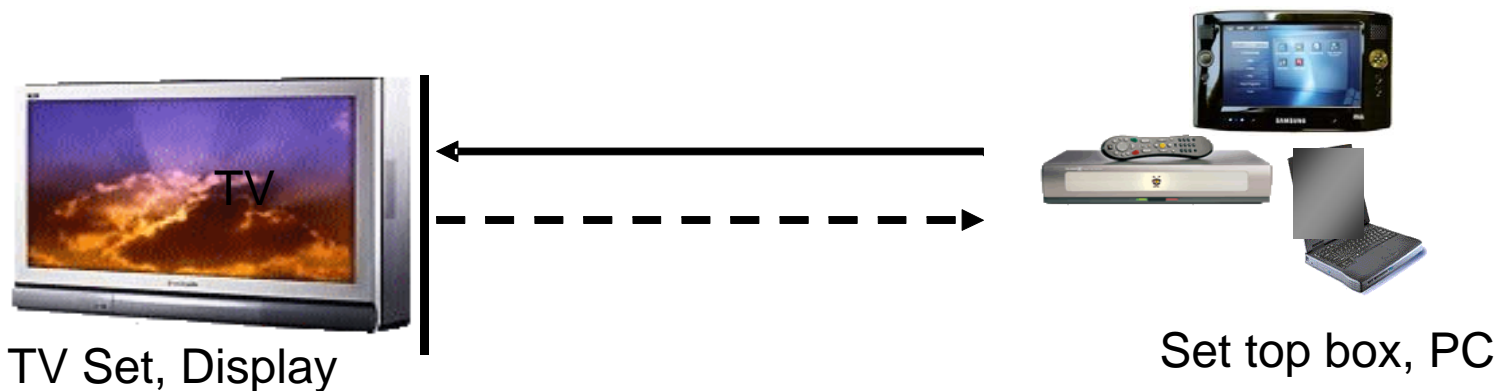
# 802.15.3c- High Rate (> 1Gbps)

## mmWave 15.3 PHY

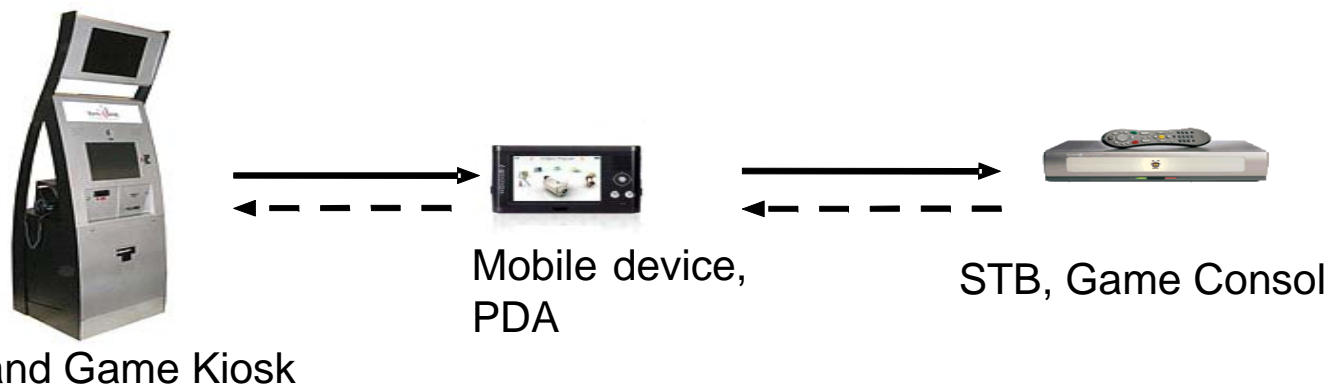
- IEEE 802.15.3c, a 60GHz PHY Amendment for 802.15.3, began in September 2009 and published in October 2009
- Key attributes include:
  - Transmission speeds of at least 1 Gbps
  - Operation in new unlicensed bands such as 57-64 GHz in the USA and 59-66 GHz in Japan and parts of Europe
  - Support for very high data rates (up to over 5 Gbps) for applications such as uncompressed video transmission, large file down/up load, ultra high speed internet access

# Typical Applications for a 60 GHz WPAN

1. Video Streaming: 3Gbps uncompressed video (transmission range : ~ 10 m)

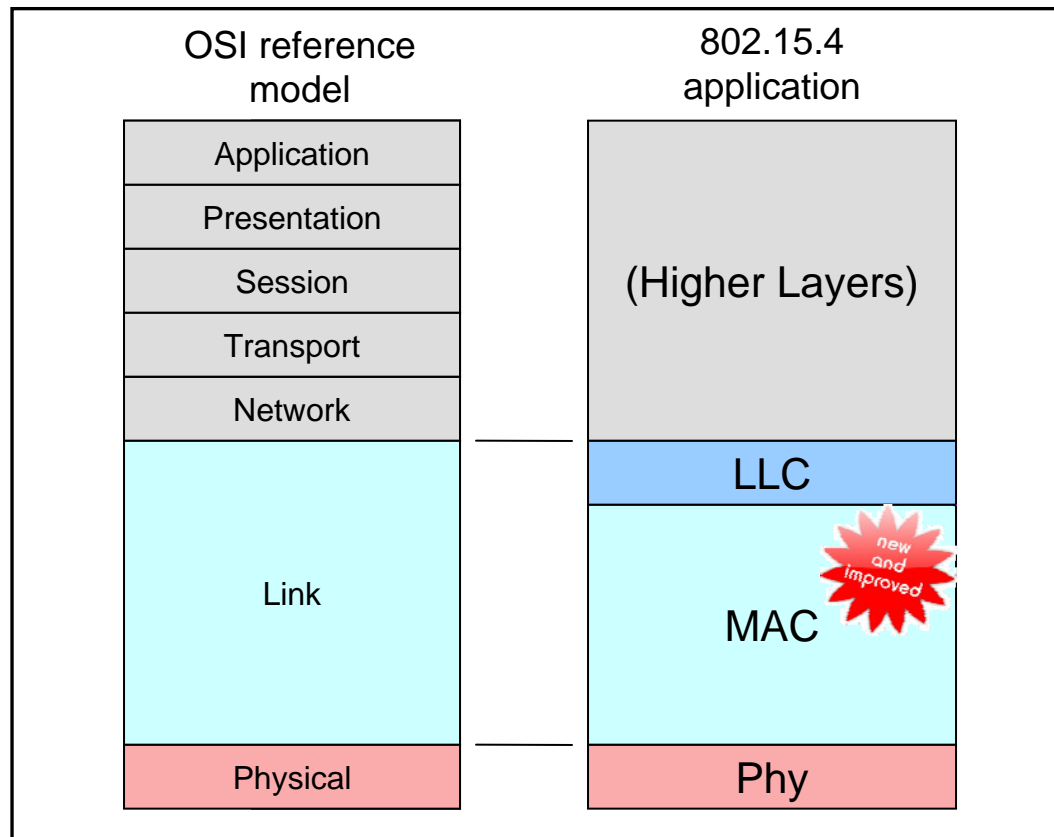


2. Kiosk File Downloading (Synch and Go) @ 1-3 Gbps  
(transmission range : 1 – 2 m) - DVD Down Load in 10 sec (@3 Gbps)



# 802.15.4e

## MAC enhancements



# 802.15.4e- MAC enhancements



- **Scope:** Amendment to the 802.15.4-2006 MAC adding:
  - TDMA: a) determinism, b) enhanced utilization of bandwidth
  - Channel Hopping: additional robustness in high interfering environments and enhanced coexistence with other wireless networks
  - GTS: a) Support for peer to peer, b) control over the length and number of slots
  - CSMA: improved throughput and reduced energy consumption
  - Security: support for options such as asymmetrical keys
  - Low latency: reduced end to end delivery

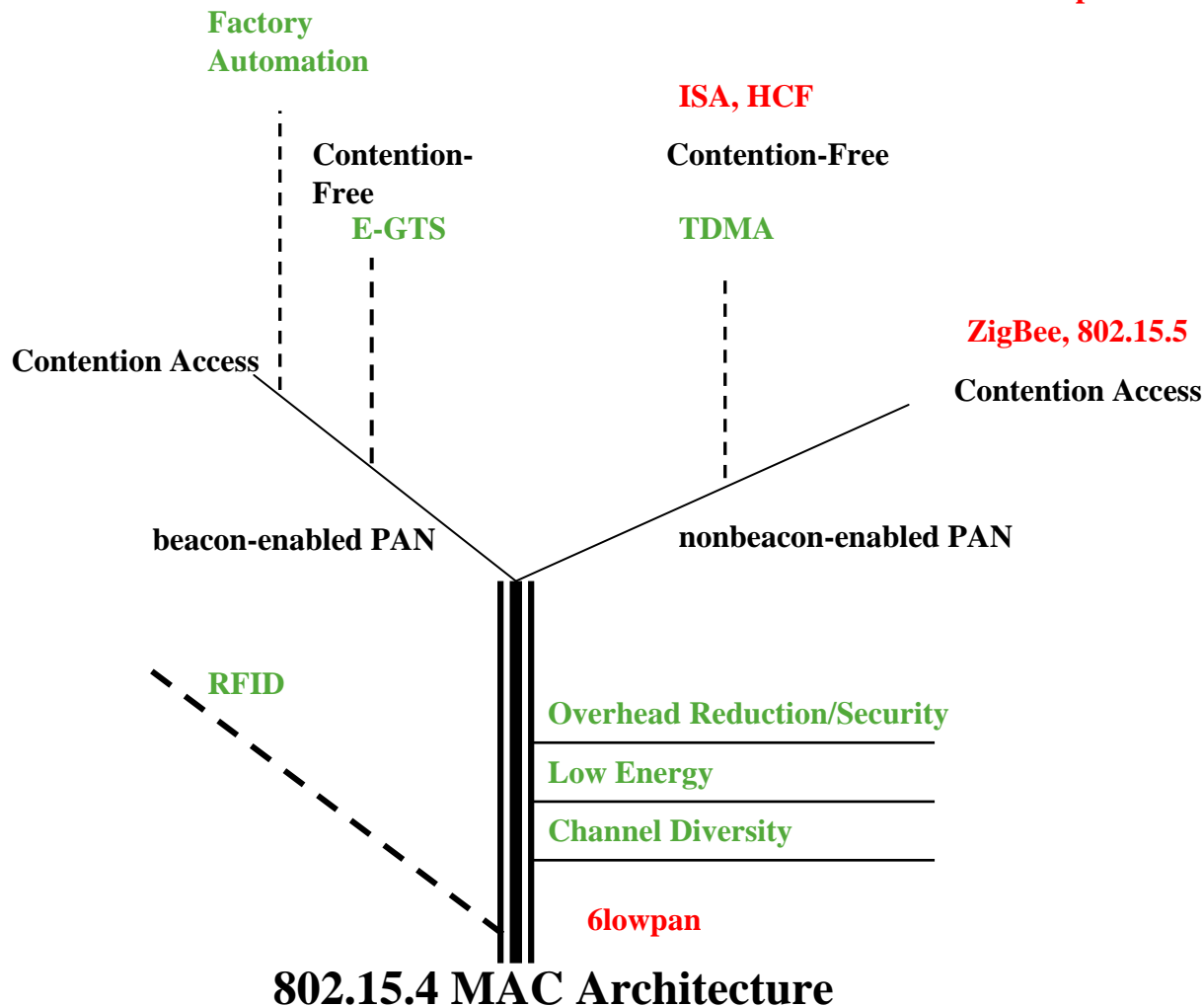
# 802.15.4e- MAC enhancements



- This proposed functionality facilitates:
  - Industrial applications (such as those addressed by HART 7 and the ISA100 standards)
  - Enhancements defined by the proposed Chinese WPAN standard.
  - MAC functionality needed for the applications served by
    - 802.15.4f PHY Amendment for Active RFID
    - 802.15.4g PHY Amendment for Smart Utility Networks

# 802.15.4e- MAC enhancements

Blue are functions added by TG4e  
Red are standards based upon 802.15.4





# 802.15.4e- MAC enhancements



## Timeline:

Technical resolutions complete	Nov 2009
Finalize Draft	Jan 2010
Work Group Letter Ballot	Feb 2010
Resolve comments & 1 <sup>st</sup> recirc	Apr 2010
Resolve comments & final recirc	Jun 2010
Start Sponsor Ballot	July 2010
Comment resolution & reballot	Oct 2010
Submit to IEEE RevCom	Dec 2010

# Active RFID

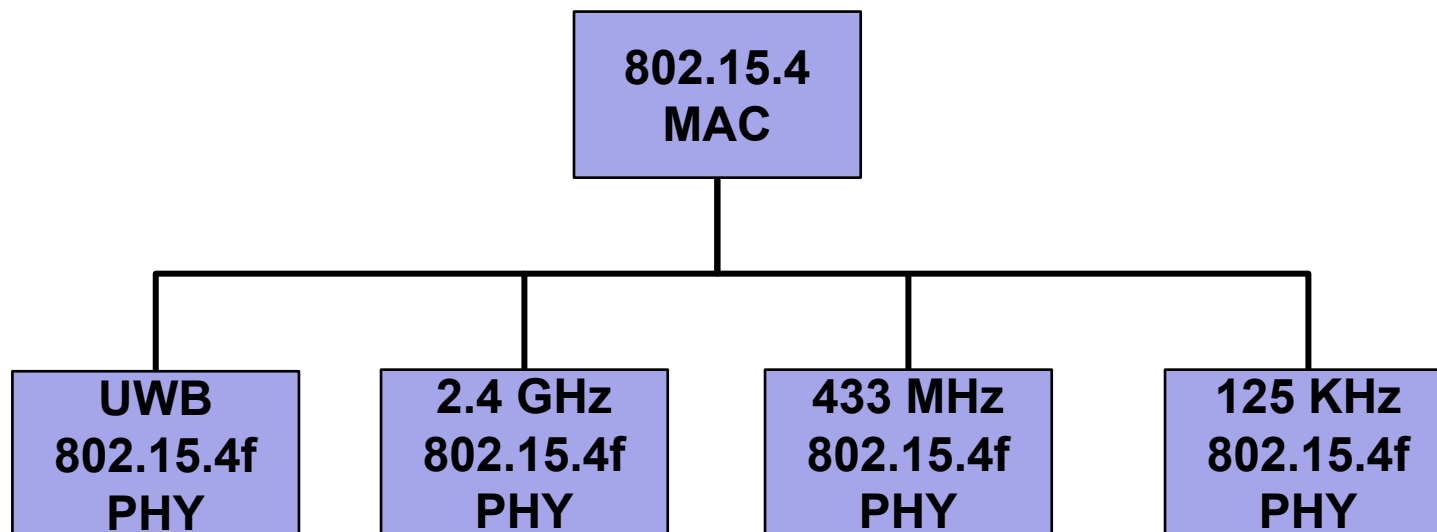
## 802.15.4f



## 802.15.4f Active RFID

- Scope: 15.4 PHY for Active RFID readers and tags having:
  - Very low energy consumption
  - Support for a variety of active RFID tag operations including simplex and duplex transmission (reader-to-tag and tag-to-readers), multicast (reader to a select group of tags), uni-cast as in reader to a single tag, tag-to-tag communication, and multi-hop.
  - Support for a large tag population (hundreds of thousands)
  - High reliability for applications such as active tag inventory counting or auditing.
  - World-wide usability, with or without licensing
  - High tolerance to interference from other devices operating within the same band
  - Proven coexistence with other 802 wireless standards operating in the same bands.

# 802.15.4f Proposed Draft Outline



# IEEE 802.15.4f Proposed Draft Outline

- Includes four frequency bands for global use
  - Ultra-Wideband (UWB)
    - 7 GHz (US), 6 or 8 GHz (EU), 10 GHz (Korea/Japan)
  - 2.4 GHz (up to 27 narrowband 750 KHz channels)
  - 433 MHz (single channel centered at 433.92 MHz)
  - 125 KHz (Magnetic) – pending verification that the 802.15.4 MAC will support this PHY.
- Requires the addition of a one-way 'BLINK' frame to the MAC

# 802.15.4f Timeline

	2008				2009												2010												2011			
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4
PAR and 5C approved	x		x																													
Call for Applications (as SG)			x																													
Task Group Formed				x																												
Call For Applications (as TG)					x																											
Technical Requirements Guidance					X		X		X																							
Selection Criteria							x		X																							
Discussion of Coexistence Criteria							x		X																							
Call for intent to propose									X																							
Call for Proposals issued									X																							
Down Selection Mechanism									X																							
Determine need for, suitability of, Channel Models									x																							
Prelim proposals heard (CFI Response)										X																						
Present Final Proposals												X																				
Baseline proposal selected (selection/merge complete)													X																			
Draft Work													x	x																		
Draft Ready for 1st letter ballot															x	x																
1st letter ballot complete																																
Resolution of comments, 1st recirc																																
1st re-circulation complete																																
Resolve comments, 2nd re-circ appr																																
2nd re-circulation complete																																
resolve comments, 3rd re-circ appr.																																
3rd re-circulation complete																																
resolve commnets, approv.																																
Sponsor																																
Sponsor Ballot																																
comments relolved																																
re-circ sponsor bolot																																

1st Letter Ballot period

2nd Letter period

3rd Le cycle p

January 2010 Interim mtg.

This timeline will slip by at least two months but with much work TG4f may remain within the 1st letter ballot cycle period.

**1st Letter Ballot cycle period**

**2nd Letter Ballot cycle period**

**3rd Letter Ballot cycle period**

**Sponsor Ballot cycles**

**January 2010 Interim mtg.**

**This timeline will slip by at least two months but with much work TG4f may remain within the 1st letter ballot cycle period.**

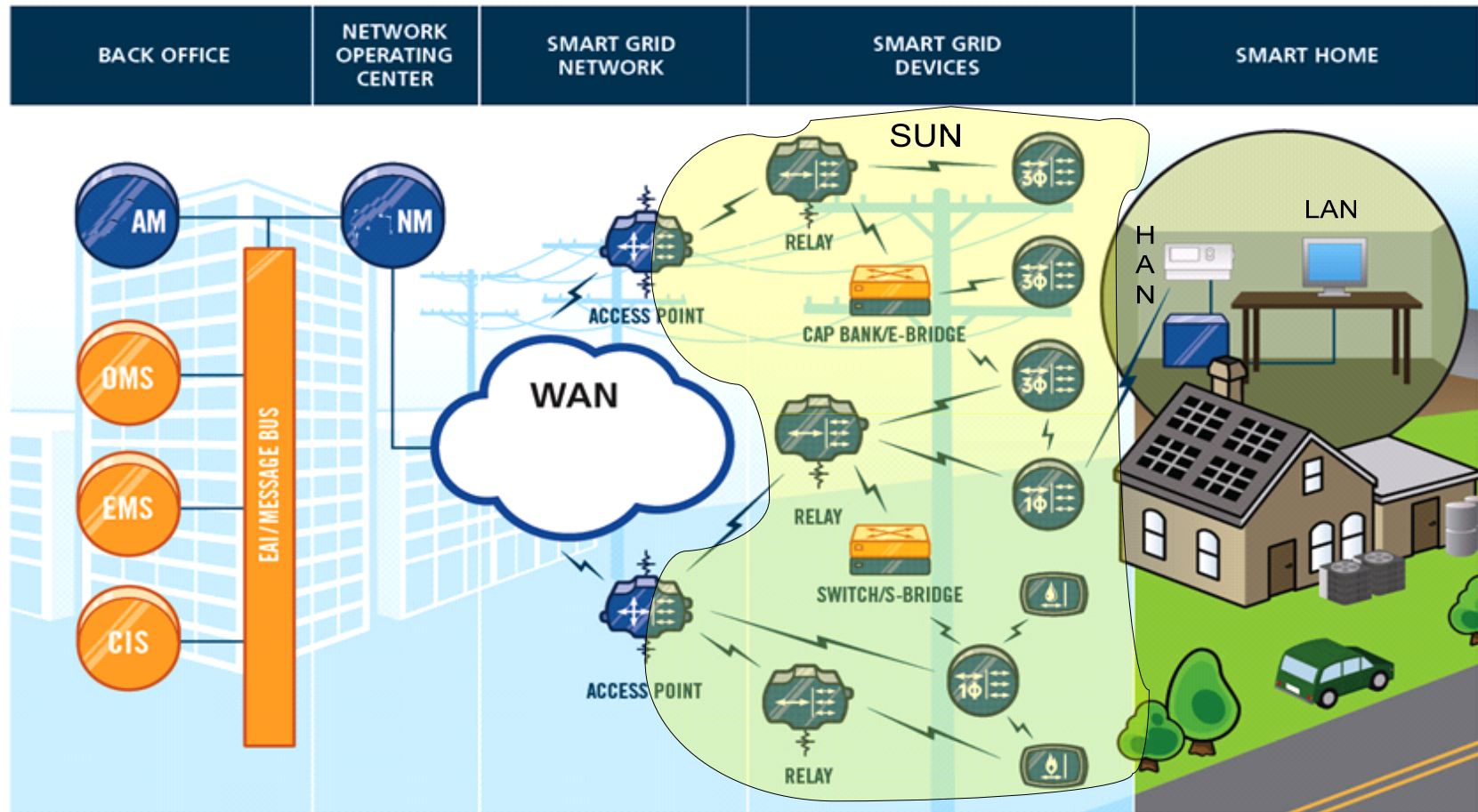
# Smart Utility Networks

## 802.15.4g



# 802.15.4g-Smart Utility Networks

## Where does it fit?





# 802.15.4g-Project Scope

- IEEE 802.15.4 PHY amendment for Wireless Smart Metering Networks supporting:
  - Operation in any of the regionally available license exempt frequency bands, such as 700MHz to 1GHz, and the 2.4 GHz band.
  - Data rates of at least 40 kbps but not more than 1000 kbps
  - Principally outdoor communications
  - Optimal energy efficient link margins given typical environmental conditions encountered in Smart Metering deployments.
  - PHY frame sizes up to a minimum of 1500 octets
  - Simultaneous operation for at least 3 co-located orthogonal networks
  - Connectivity to at least one thousand direct neighbors characteristic of dense urban deployment
  - Coexistence with other 802 systems in the same band(s)
  - Mesh Networking

## 802.15.4g-Current Status and Activities

### November 2009

- Addresses North America, Europe, Japan, Korea and Chinese Regulatory domains
- Merged to 3 proposals - 1 FSK, 1 DSSS, 1 OFDM
- Agreement to create a candidate draft in preparation for 802.15 letter ballot following the January meeting
- Providing input to NIST Priority Action Plan #2

# 802.15.4g-Areas of current active debate

## November 2009

- Technical issues still to be resolved as part of merging activity:
  - DSSS proposal
    - Harmonization of spreading modes
    - Mode selection mechanisms
    - Best method to support 802.15.4-2006 OQPSK
  - FSK proposal
    - Packet format for the PHY rate switching option
    - Define Start of Frame Delimiters & Preamble values and lengths
    - Agree on FEC solution for header and payload
    - Verify Option #2 Parameter - GFSK or FSK?
    - Agree on scrambling mechanism
    - Agree on data rate sets for Europe and China
    - Complete definition of PIB attributes

# 802.15.4g-Areas of current active debate

## November 2009

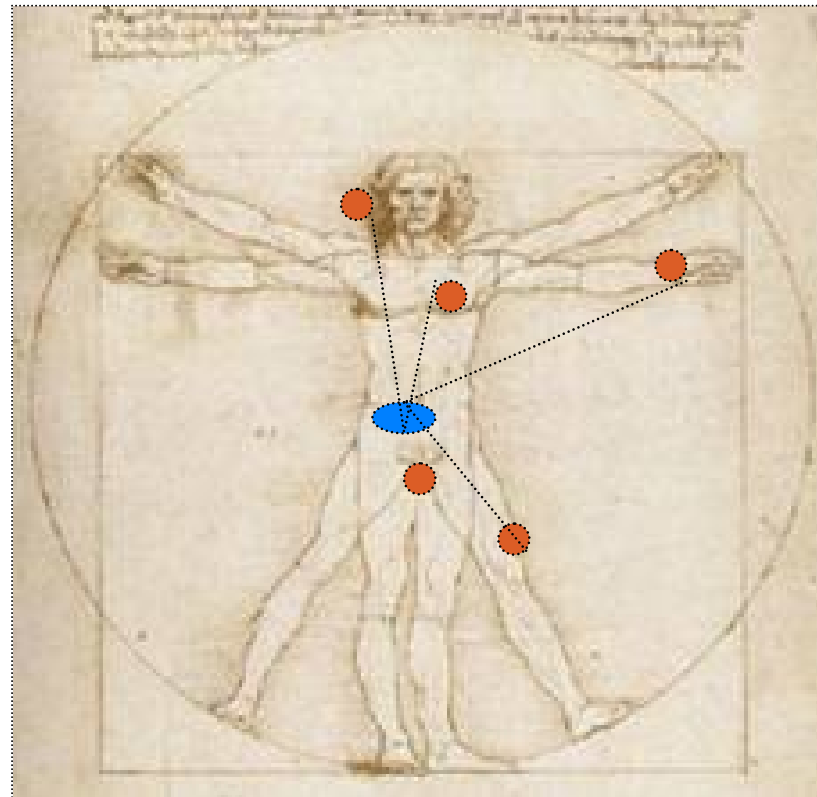
- The group has agreed that it is unlikely that a single PHY definition can address such a broad application space,
  - Benefits of FSK are
    - Low Risk--Robust, simple and proven technology for this application
    - Can use 1 watt transmit power, giving good range
  - Benefits of OFDM are
    - Higher data rates-- future applications may require more data , lower latency etc
    - Multipath mitigation-- potential problem with higher data rates using FSK
  - Benefits of DSSS are
    - Extended range with lower data rates -- important for sparse, rural deployments
- The details of coexistence and interoperability are still be agreed
  - Coexistence and Interoperability is being studied in a subgroup
- Aggressive schedule to have text ready in time to agree candidate draft at January meeting

# 802.15.4g-SUN Schedule

Meeting Date	Milestones / Objectives
Nov-09	Agree on content for Baseline Draft
Jan-10	Finish draft for Working Group Letter Ballot
Mar-10	Comment resolution, 1 <sup>st</sup> recirc
May-10	Comment resolution, 2 <sup>nd</sup> recirc
Jul-10	Comment resolution, prepare for sponsor ballot
Sep-10	Comment resolution, 1 <sup>st</sup> recirc
Oct-10	Complete comment resolution, 2 <sup>nd</sup> recirc
Dec-10	Submit to RevCom

# Body Area Networks (BAN)

## 802.15.6 Overview



## 802.15.6 Body Area Networks

- Scope: Standard for short range, wireless communication in the vicinity of, or inside, a human body (but not limited to humans)
  - Uses existing ISM bands and/or bands approved by national medical and/or regulatory authorities
  - Supports QoS, extremely low power, & data rates up to 10 Mbps
  - Complies with strict non-interference guidelines where needed
  - Considers effects on portable antennas due to the presence of a person (varying with male, female, skinny, heavy, etc.)
  - Meets Specific Absorbed Radiation Limits
  - Accommodates user motions

# 802.15.6 BAN Applications

## Physiological and vital signals monitoring

- Temperature monitor
- Blood pressure sensor
- Mechanical motion sensors
- Respiratory monitor
- Breathing monitor
- Saturation of Peripheral Oxygen (SpO2) - pulse oximeter
- Heart rate monitor
- Cardiac arrhythmia monitor/recorder
- Electro Cardiogram (ECG)
- pH value sensor
- Glucose sensor
- Electro Encephalography (EEG )
- Electromyography (EMG) (muscular)
- Brain liquid pressure sensor
- Fertility Monitor
- Endoscope (gastrointestinal)



# 802.15.6 BAN Applications

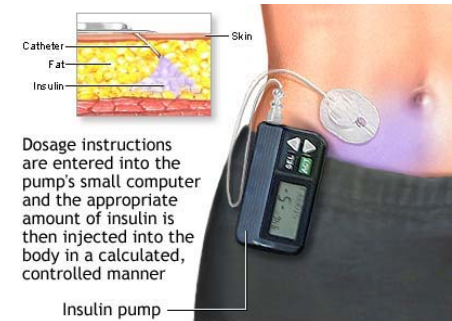
## Stimulators

- Deep brain stimulator
- Cortical stimulator
- Visual neuro-stimulator
- Audio neuro stimulator
- Parkinson's disease
- Epilepsy Stimulator
- Brain-computer interface
- Wireless capsule for drug delivery

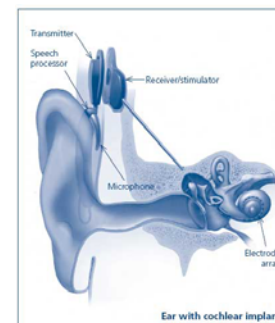
# 802.15.6 BAN Applications

## Remote control of medical devices

- Pacemaker
- Implantable Cardioverter Defibrillator (ICD)
- Actuators
- Insulin pump
- Deep brain stimulator
- Hearing aids
- Implantable Hearing Aids
- Cochlear implant
- Retina implants
- Muscular signal replacement



Dosage instructions are entered into the pump's small computer and the appropriate amount of insulin is then injected into the body in a calculated, controlled manner

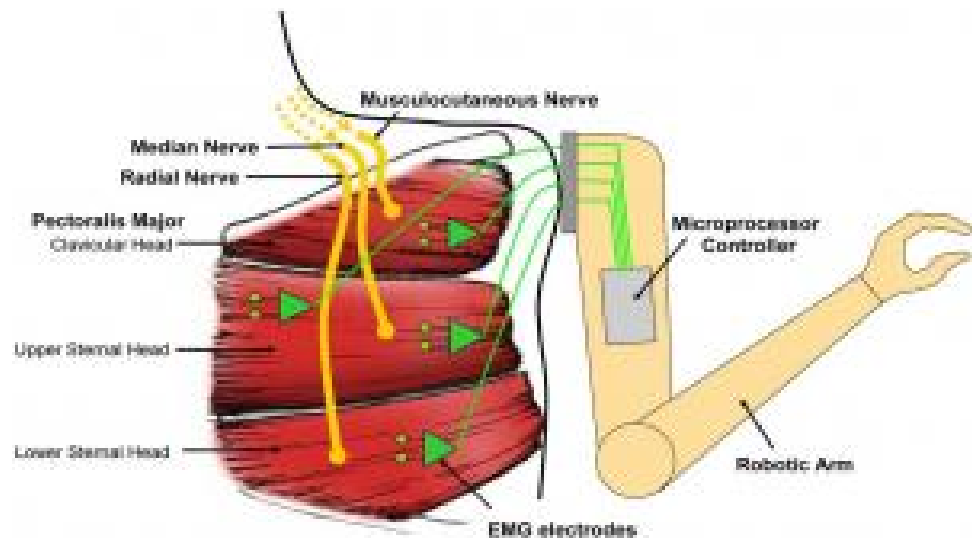


ADAM

# 802.15.6 BAN Applications

## Disability assistance

- Muscle tension sensing and stimulation
- Wearable weighing scale
- Fall detection
- Aiding sport training



*Diagram of the new prosthetic arm, still under development, which will respond directly to the brain's signals. (Credit: Journal of Neurophysiology)*

# 802.15.6 BAN Applications

## Elderly People Assistance

- Tilt sensors for monitoring accident fall-down.
- Foot sensors for monitoring steps.
- Breathing sensor for monitoring respiration.
- Blood pressure sensor.
- Movement sensors for monitoring activities.
- Heart rate
- Body temperature.

# 802.15.6 BAN Applications

## Fitness Monitoring

- Speed
- Distance
- Heart rate
- Respiration monitor
- Temperature sensor
- Pacing information
- Location information
- Wristwatch display unit



# 802.15.6 BAN Applications

## Wearable Audio - Video

- Central device is headset
  - Earset
  - Eyeset
- Stereo audio, microphone
- Video
  - Camera sensor
  - Display
- Connected devices
  - Cellular phone
  - Audio/Video Player
  - AP at home
  - AP in car



## 802.15.6 Channel Model Challenges

- The channel model will include body effects.
  - Specific Absorption Rate (SAR), health effects
  - Body shadowing causes severe attenuation at some frequencies
  - User motion causes large variations in channel
  
- New channel models are needed
  - Access point to surface of body
  - Surface of body to surface of body
  - Surface of body to inside body
  - Inside body to inside body

Swallowable camera



Implanted  
glucose sensor



Implanted  
Insulin pump

# 802.15.6 Potential Frequency Bands

- **Medical Implant Communications System (MICS)** band 402-405 MHz, USA, EU, Korea, Japan (FCC 47 CFR 95.601-95.673 Subpart E)
  - 10 channels of 300kHz
  - Adaptive frequency agility
  - 25uW EIRP
- **Med Radio** FCC proposed band 401 - 402 MHz and 405 - 406 MHz
- **Wireless Medical Telemetry Service (WMTS)** Band  
608 – 614 MHz (TV ch 37), 1395 – 1400 MHz, 1427 – 1432 MHz
- **Industrial, Scientific & Medical (ISM)** Band  
868/915MHz, 2.4GHz, 5.8GHz
- **UWB** Band
- **RFID** links: 135kHz, 6.78MHz, 13.56MHz (ERC Rec 70-03)
- **Inductive** Link band 9kHz - 315kHz (ECC Report 12)
- **Capacitive** carrier less baseband transmission



# 802.15.6 Draft Status

## **UWB PHY**

CSEM  
NICT-YNU-Meiji-UWB-phy-proposal  
IMEC OR  
CEA-FT-Thales  
TI  
ETRI-Samsung

## **Narrowband PHY**

ETRI  
IMEC GD  
KETI, KORPA, (LG), Tensorcom,  
(Mitsubishi)  
Zarlink  
Inha  
NICT, MedWin, Fujitsu  
Motorola

## **HBC PHY**

ETRI-Samsung HBC

## 802.15.6 Current issues to resolve

### ■ PHY

- Narrowband -- MICS in Japan, reconcile with ETSI rules in Europe
- Ultra wideband-- Impulse Radio or FM
- Skin Conduction-- reconcile with safety regulations

### ■ MAC

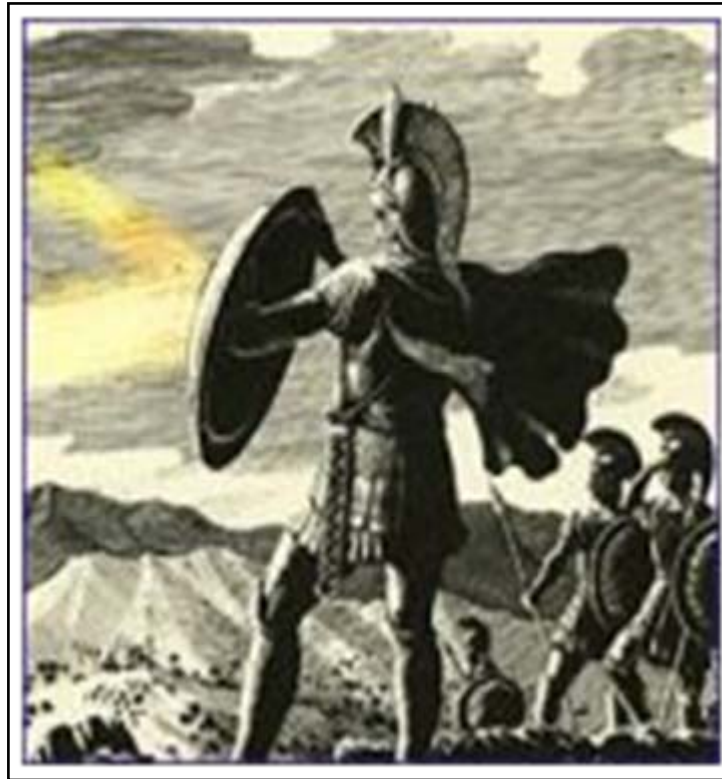
- Beacon versus polling
- Security method

# 802.15.6 BAN Timeline 2010

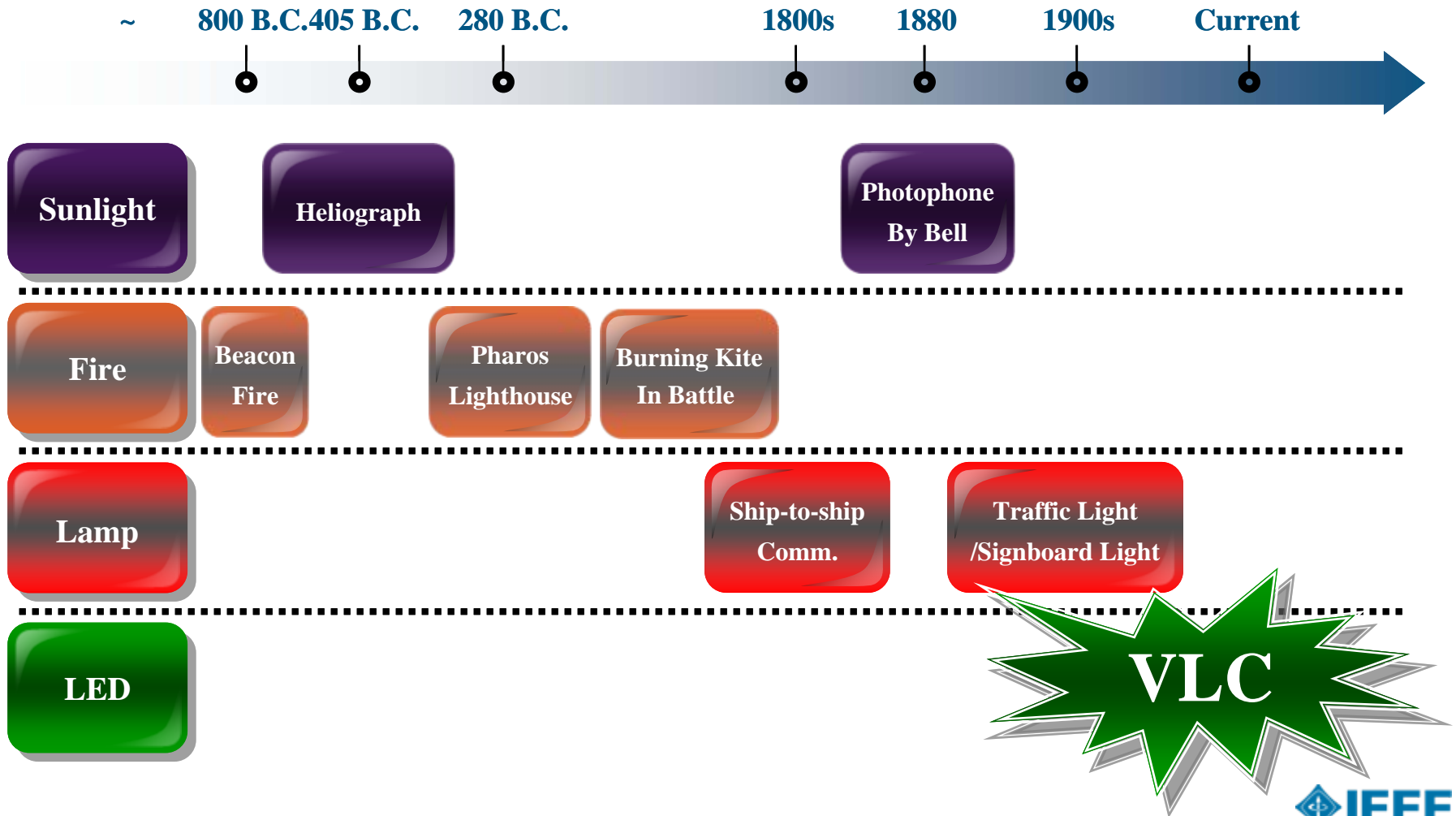
	2009				2010											
	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Merge Proposals	>	>	>	>	>											
Agree on content for Baseline					>											
Draft Work				>	>	>										
Draft Completion							>	>	>							
Draft Ready for 1st letter ballot									>							
1st letter ballot complete										>	>					
Resolution of comments											>	>	>			
1st re-circulation complete													>			
Resolve comments													>	>	>	
2nd re-circulation complete															>	
Resolve comments, 3rd recirculation apprv.															>	>

# Visible Light Communications (VLC)

## 802.15.7

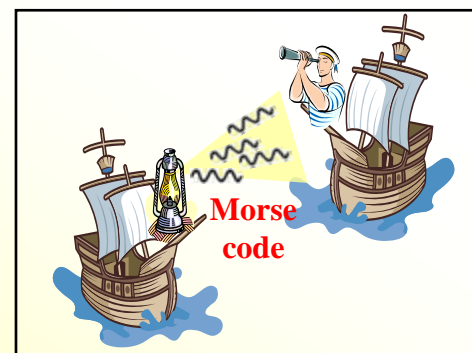


# VLC history



# VLC history – Low speed

- ❖ Information delivery through reflection by mirror (Heliograph)
- ❖ The use of fire or lamp
  - Beacon fire, lighthouse, ship-to-ship comm. by Morse code
- ❖ Traffic light : signal discrimination by color (Walk/Stop)



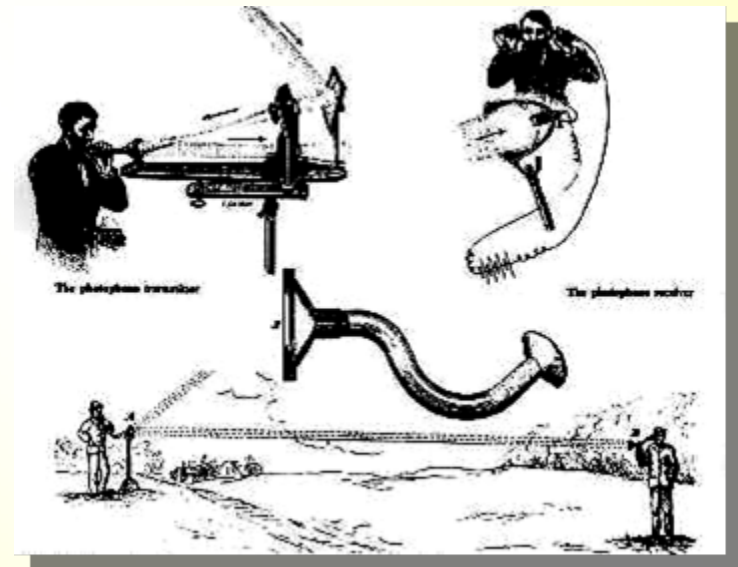
# VLC history - Photophone

## ❖ Bell's Photophone (1880)

- Optical source : sunlight
- Externally modulation by vibrating mirror
- Receiver : parabolic mirror with crystalline selenium cells
- 700 ft (213m) sound transmission



<http://www.freespaceoptic.com/>



Excerpted from: The New Idea Self-Instructor edited by Ferdinand Ellsworth Cary, A.M. (Monarch Book Company, Chicago & Philadelphia, 1904)

# 802.15.7 Visible Light Communications

- **Scope: defines a PHY and MAC for short-range optical wireless communications using visible light in optically transparent media**
  - Spectrum extends from 780 to 380 nm in wavelength (~400-800 THz)
  - Data rates supporting audio and video multimedia services
  - Adherence to any applicable eye safety regulations.
  - Fixed and mobile visible links
  - Resistance to noise and interference from sources like ambient light



# 802.15.7 Visible Light Communications

## ■ **Purpose: Provides means to**

- Access to several hundred THz of unlicensed spectrum
- Avoid electromagnetic and RF interference
- Provide additional security by allowing the user to see the communication channel
- Augment and complement existing services (such as illumination, display, indication, decoration, etc.) from visible-light infrastructures.



# 802.15.7 Visible Light Communications

- **Need: Visible light is drawing great interest as a new (rediscovered?) communication medium due to the following recent developments.**

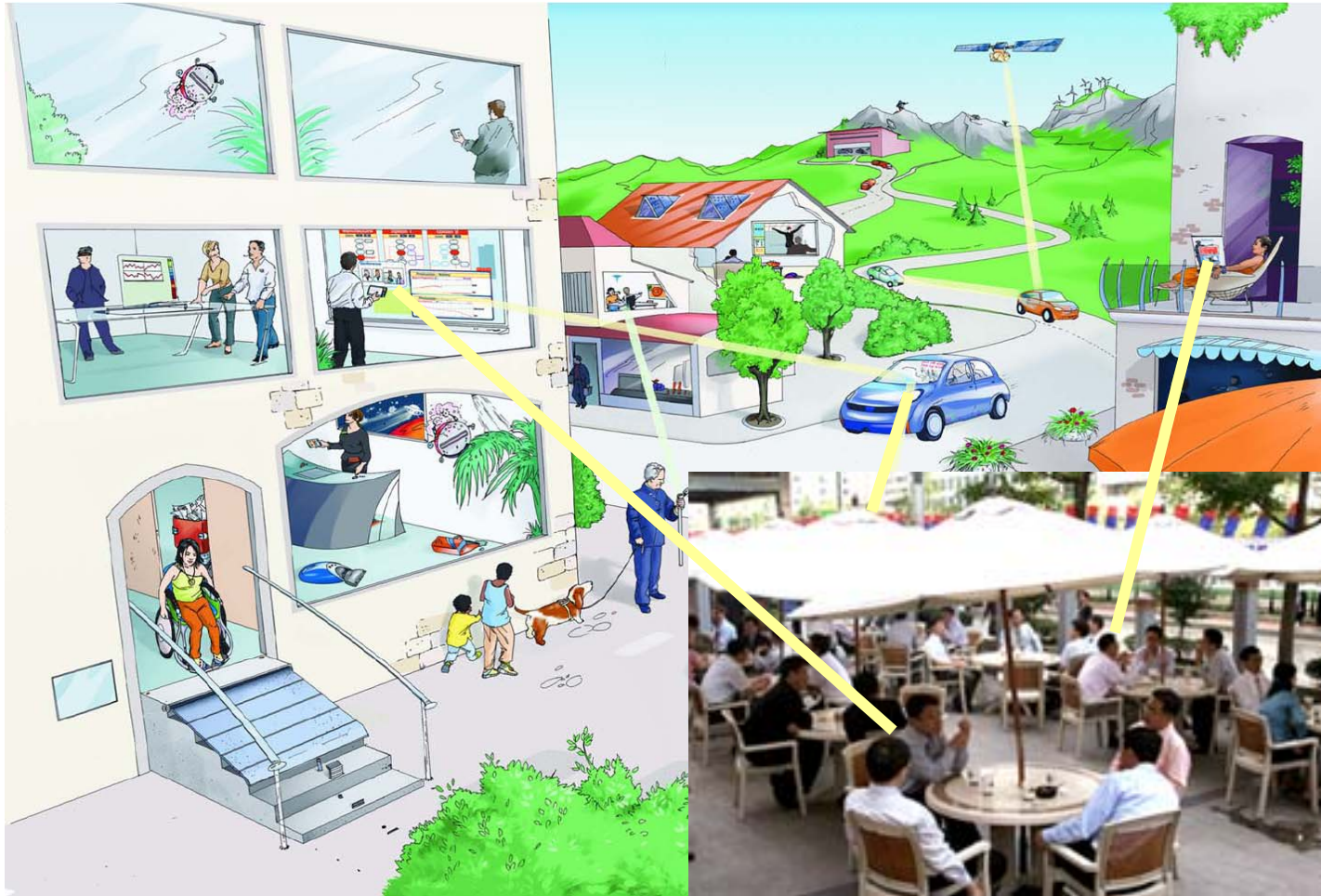


- LED sources are rapidly replacing conventional ones in signaling, illumination and display infrastructures.
- Visible band is free from Radio Frequency (RF) regulations and interference
- Well suited for use in RF crowded or RF restricted environments.
- Visibility can enhance the physical-layer security and offer intuitive usage.
- Potential applications include secure point-to-point communication, indoor Location Based Service (LBS), secure Point-to-Multipoint communication (office, hospital, airplane), Intelligent Transportation System (ITS), information broadcast, and etc.

# 802.15.7-VLC Application Scenarios



# ❖ 802.15.7 -VLC, Ubiquitous Connectivity



# 802.15.7 Visible Light Communications



## ■ Opportunity:

- Novel new wireless communications which does not fit in any real category within 802
  - kind of thing 802.15 does
- Rapid adoption of a global base standard establishes a platform for consistent growth and development in a open standards environment as technology and application opportunities emerge
- Targeting end of 2010 for completion



## Questions?

Bob Heile, Chair IEEE 802.15

[bheile@ieee.org](mailto:bheile@ieee.org)

[www.ieee802.org/15](http://www.ieee802.org/15)