IEEE 802 Wireless Workshop

Pulvermedia FMC, Chicago

5 September 2007

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President, octoScope

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- President of octoScope, consulting company focusing on
  - RF and wireless design
  - Network or device architecture
  - Performance verification
  - Product or architecture advocacy
- Founder and Chief Technology Officer, Azimuth Systems, leading wireless test platform for Wi-Fi and WiMAX test (10/01 – 10/06)
- R&D Manager, General Manager, Agilent Technologies for the WireScope handheld network certification and monitoring products (10/98 – 10/01)
- BS/EE, BA/CS Columbia University

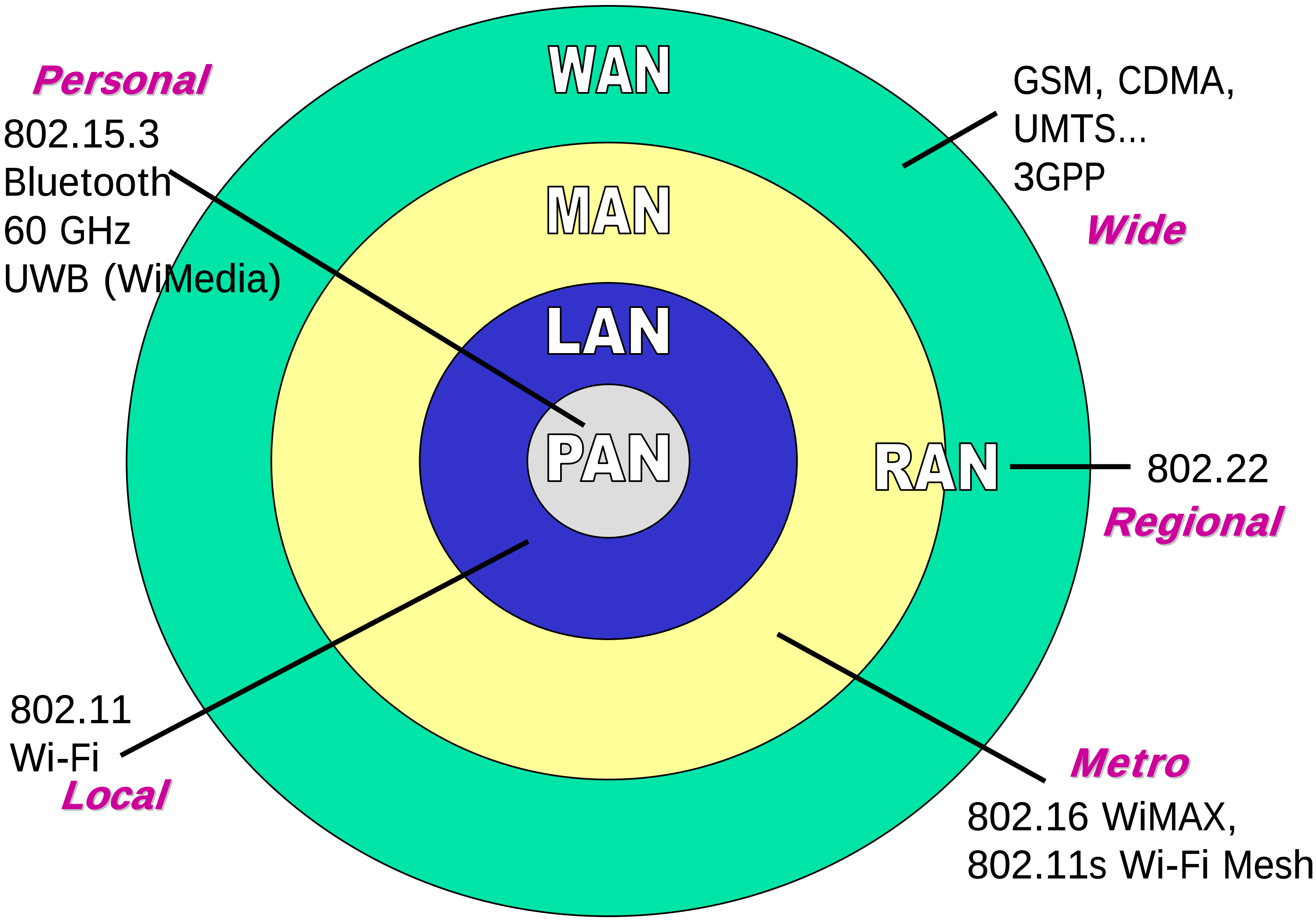
Azimuth Test Platform

Agilent WireScope

Agenda

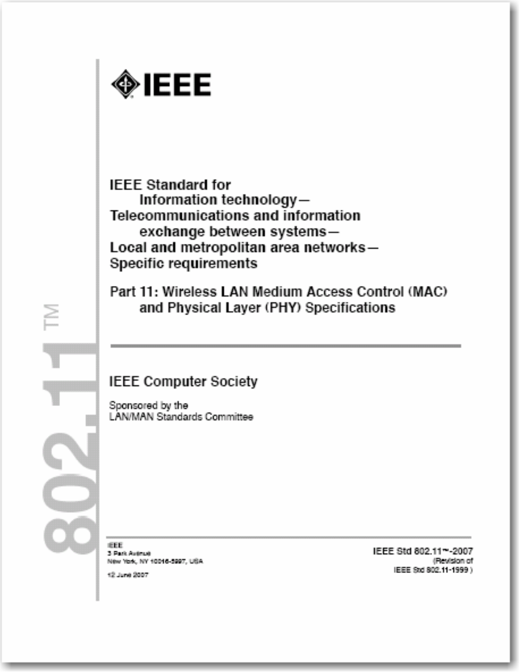
- 9:00 – 10:15 am Overview of the IEEE 802 standards
- 10:15 – 10:25 am Break
- 10:25 – 11:40 am Innovations from the Task Groups
- 11:40 – 11:50 am Break
- 11:50 – 1:05 pm Real World Experience with WLANs
  - Dorothy Stanley, Senior Standards Architect, Aruba Networks
  - Geri Mitchell-Brown, Wi-Fi Strategist and Director of Technical Business Development, SpectraLink, now a part of Polycom
- 1:05 – 2:05 pm Lunch
- 2:05 – 3:20 pm Practical Experience with Prioritization and Mesh Networking Strategies
  - Mathilde Benveniste, Research Scientist, Avaya Labs
  - Fanny Mlinarsky, President, octoScope

Wireless Communications



IEEE 802 LAN/MAN Standards Committee (LMSC)

- **802.1** Higher Layer LAN Protocols
- **802.3** Ethernet
- **802.11** Wireless LAN
- **802.15** Wireless Personal Area Network
- **802.16** Broadband Wireless Access
- **802.17** Resilient Packet Ring
- **802.18** Radio Regulatory TAG (technical advisory group)
- **802.19** Coexistence TAG
- **802.21** Media Independent Handoff
- **802.22** Wireless Regional Area Networks


802.11™

IEEE

IEEE Standard for
Information technology—
Telecommunications and information exchange between systems—
Local and metropolitan area networks—
Specific requirements

Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications

IEEE Computer Society

Sponsored by the
LAN/MAN Standards Committee

IEEE Std 802.11™-2007
(Revision of
IEEE Std 802.11-1999)

Wireless standards dominate the work of IEEE 802

ITU-T Framework

ITU-T – United Nations telecommunications standards organization

Accepts detailed standards contributions from 3GPP, IEEE and other groups

IEEE 802.11 – WLAN (wireless local area network)

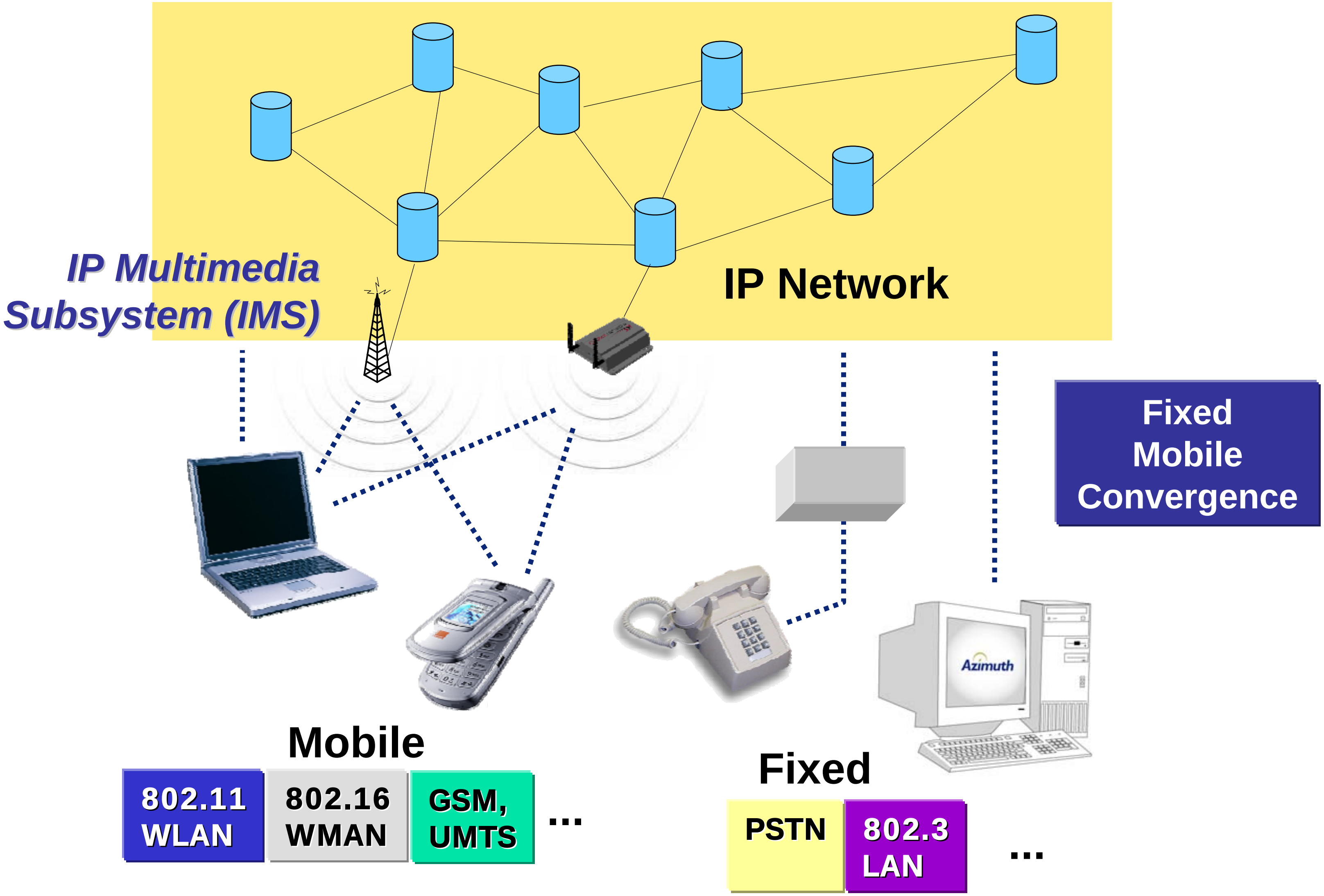
IEEE 802.16 – WMAN (wireless metropolitan area network)

3GPP – WWAN (wireless wide area network, cellular)

ITU International Mobile Telecommunications

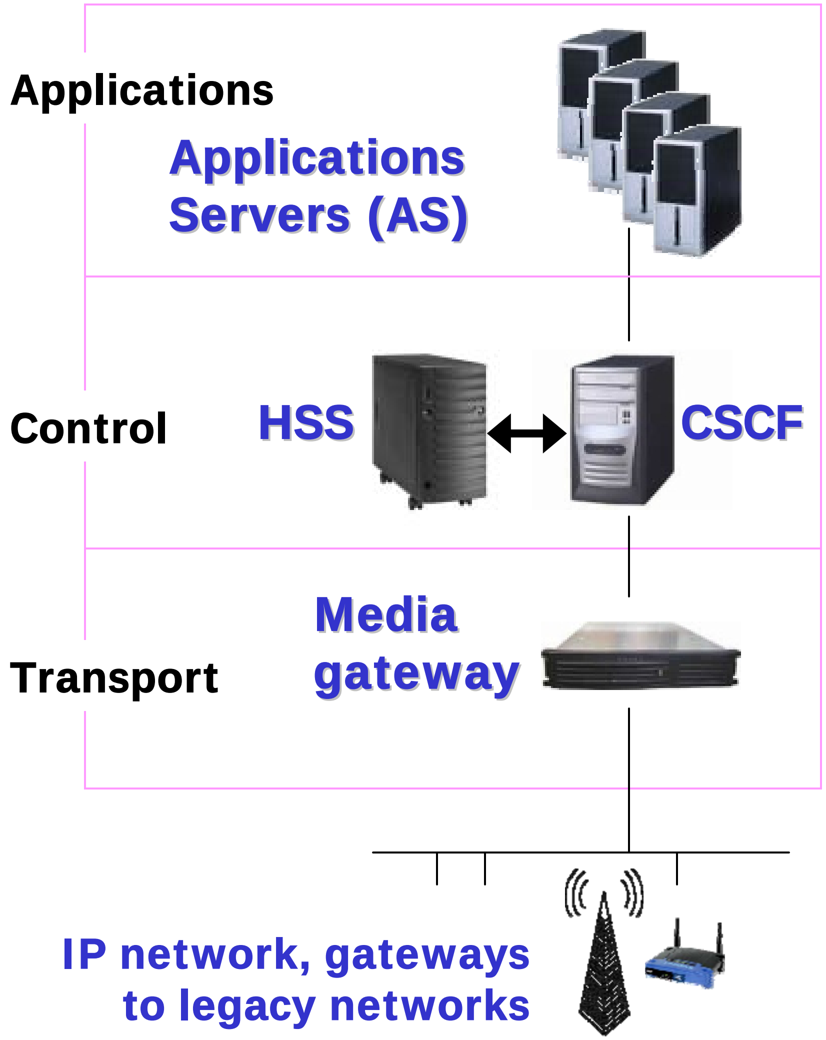
- **IMT-2000**
  - Global standard for third generation (3G) wireless communications
  - Provides a framework for worldwide wireless access by linking the diverse systems of terrestrial and satellite based networks.
  - Data rate limit is approximately 30 Mbps
  - Detailed specifications contributed by 3GPP, 3GPP2, ETSI and others
- **IMT-Advanced**
  - New generation framework for mobile communication systems beyond IMT-2000 with deployment around 2010 to 2015
  - Data rates to reach around 100 Mbps for high mobility and 1 Gbps for nomadic networks (i.e. WLANs)
  - IEEE 802.16m working to define the high mobility interface
  - IEEE 802.11 VHT SG (very high throughput study group) working to define the nomadic interface

IMS Infrastructure for FMC

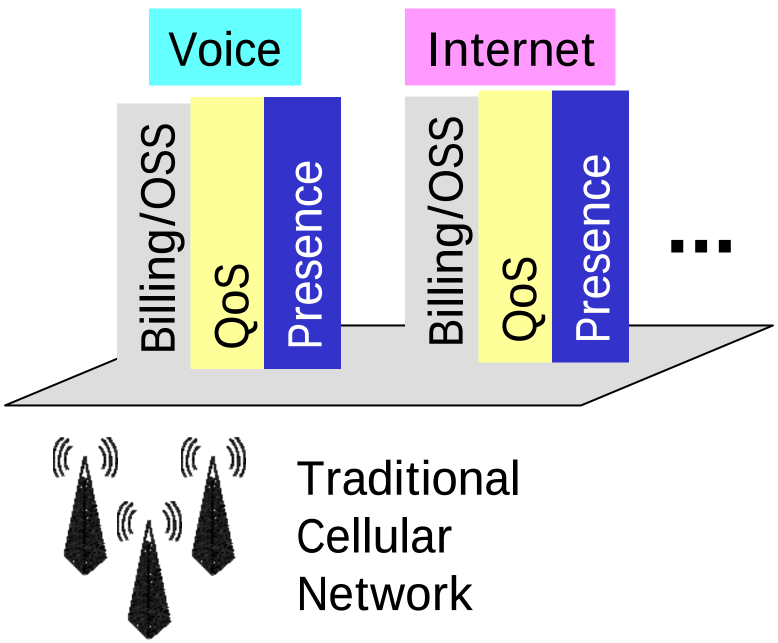


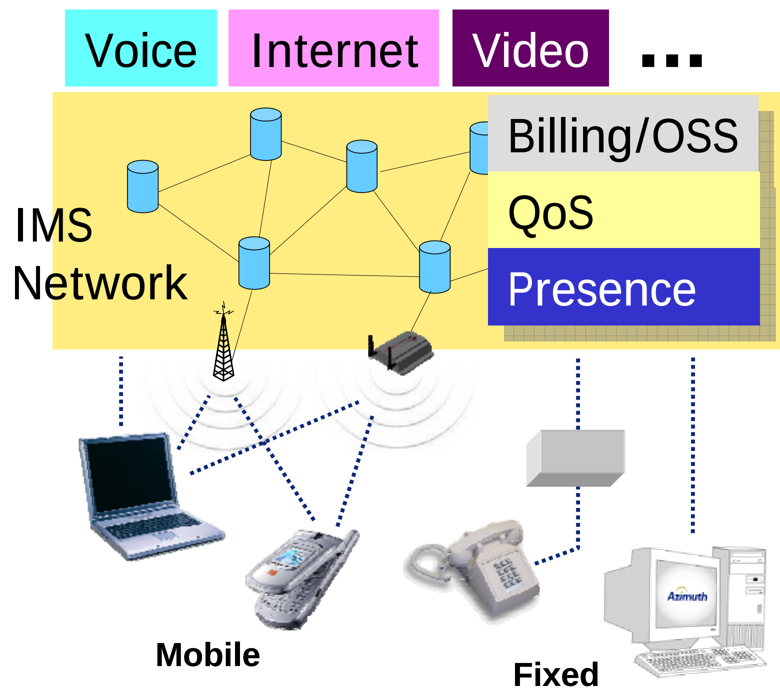
Key Components of the IMS Architecture

- **CSCF (call session control function)**
  - Heart of IMS architecture
  - Handles multiple real-time IP based services (voice, IMM, streaming video, etc.)
  - Responsible for registering user devices and for ensuring QoS
- **HSS (home subscriber server)**
  - Central repository for customer data
  - Interfaces with operators HLRs (home location registers), which keep subscriber profiles
  - Enables roaming across distinct access networks
- **AS (application server)**
  - Delivers services, such as gaming, video telephony, etc.
  - Types of AS: SIP, Parlay X, customized legacy AS



IMS vs. Traditional "Stovepipe"

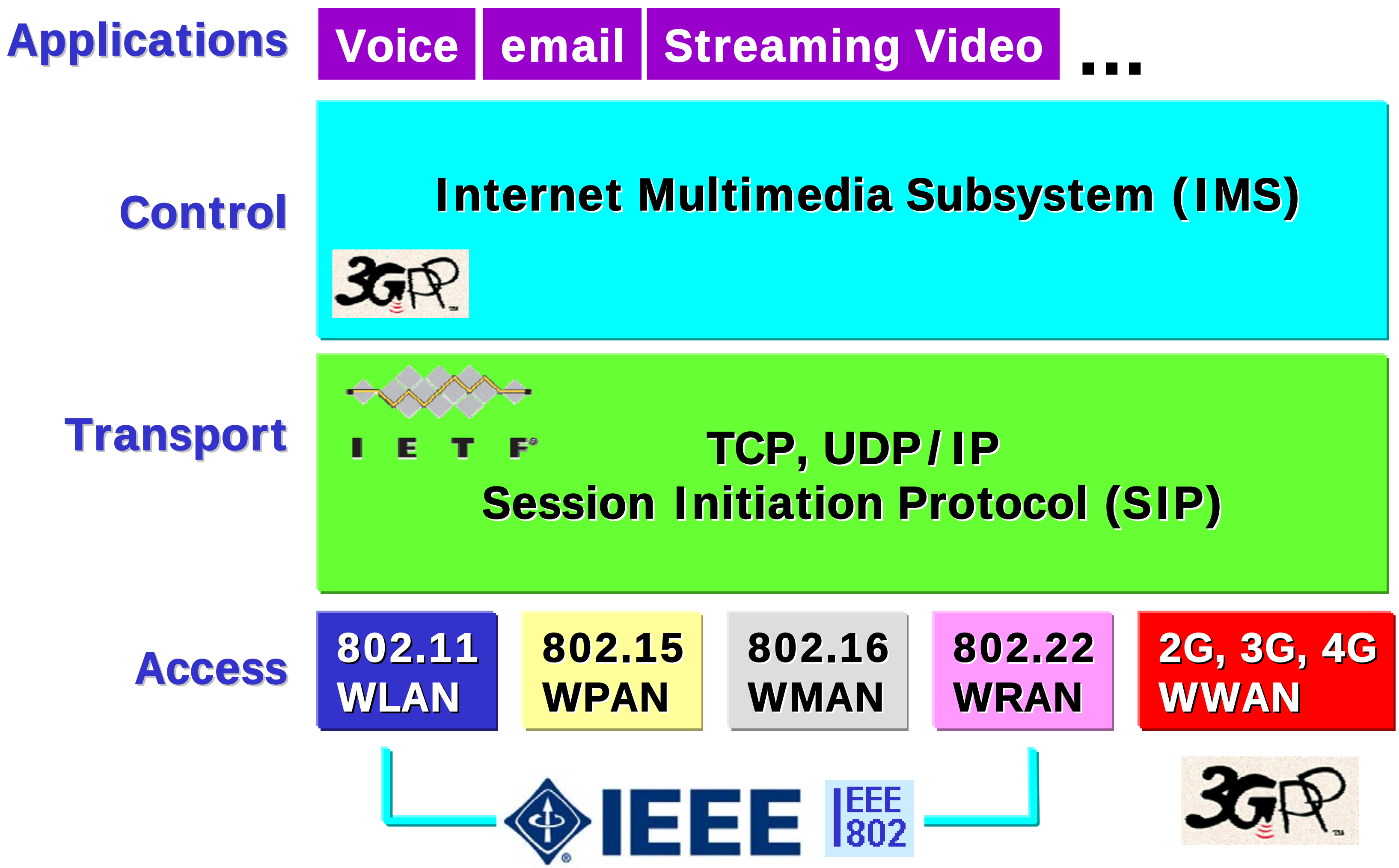




Stovepipe model – replicates functionality

IMS – common layers facilitate adding services

Standards Jigsaw Puzzle



Missing Link between IEEE 802 and 3GPP IMS?

- Liaison exists between 802.21, 802.11u, 802.16g and 3GPP
- 802.21 – MIH (media independent handover)
  - GAS (generic advertising service) gives stations information about 802.11 and 802.16 networks – SSP, SSID, radio, available services, etc.
  - 802.11u and 802.16g are defining protocols to let a station to access the 802.21 information server
- 802.11u, 802.16g – Interworking
  - Cellular-like network discovery with information on service providers, QoS, emergency call support (e911), roaming, location and availability
  - SSP (service subscription provider) – carrier or operator

working to make 802 wireless networks more like cellular

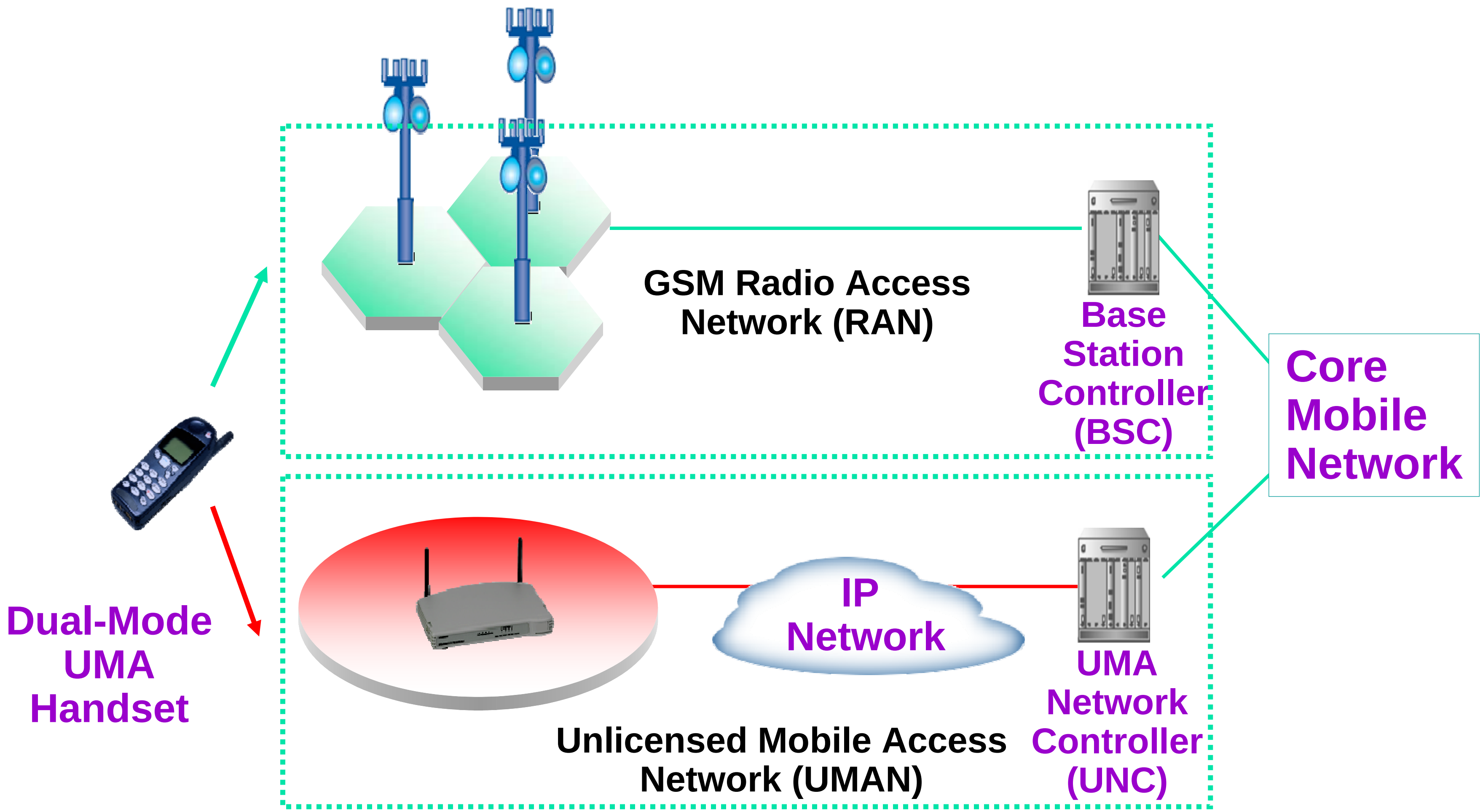
Standards for FMC

- **3GPP- IMS**
  - **GAN/UMA *2G***
  - **VCC *3G/4G***
  - **I-WLAN (no handoff)**
- **IEEE**
  - **802.11n, k, u, v, y, s**
  - **802.16e, g, m**
  - **802.21**

GAN / UMA
GSM-WiFi phones

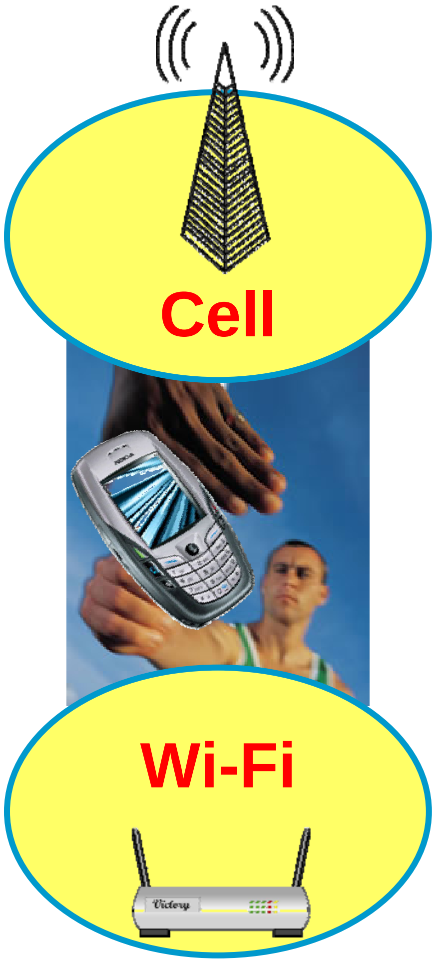
GAN = generic access network
UMA = unlicensed mobile access
VCC = Voice Call Continuity
I-WLAN = Interworking-WLAN
IMS = internet multimedia subsystem

GAN/UMA


GSM Radio Access
Network (RAN)
Base
Station
Controller
(BSC)
Core
Mobile
Network
Dual-Mode
UMA
Handset
IP
Network
UMA
Network
Controller
(UNC)
Unlicensed Mobile Access
Network (UMAN)

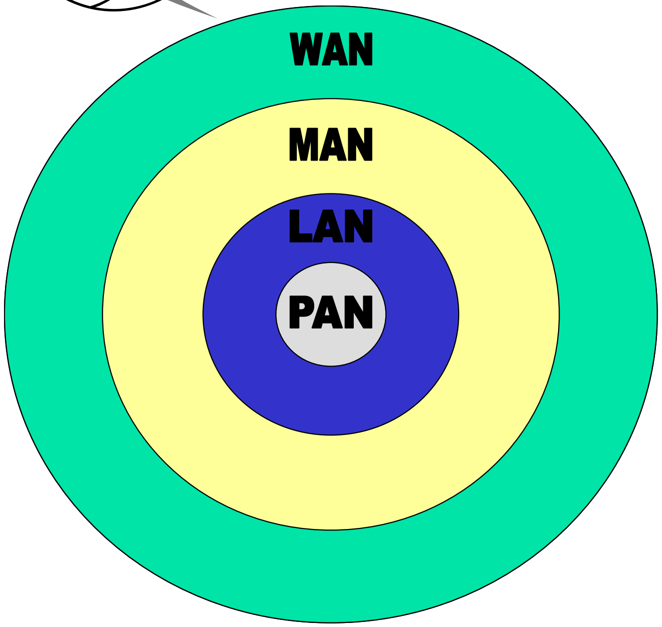
3GPP GAN vs. VCC

- **GAN (generic access network)** is a simple protocol for GSM networks only
  - Uses GSM call setup
  - Gives GSM users access to high speed data via Wi-Fi hotspots
  - Call continuity across Wi-Fi and GSM domains
  - Does not offer benefits of IMS
- **VCC (voice call continuity)** is an IMS protocol for seamless call handoff between any 3GPP networks
  - SIP (session initiation protocol) based connection management
  - GSM, UMTS, W-CDMA, Wi-Fi, etc.
  - WiMAX not officially accommodated by VCC with LTE (Long Term Evolution) technology emerging instead



ITU-T and ITU-R

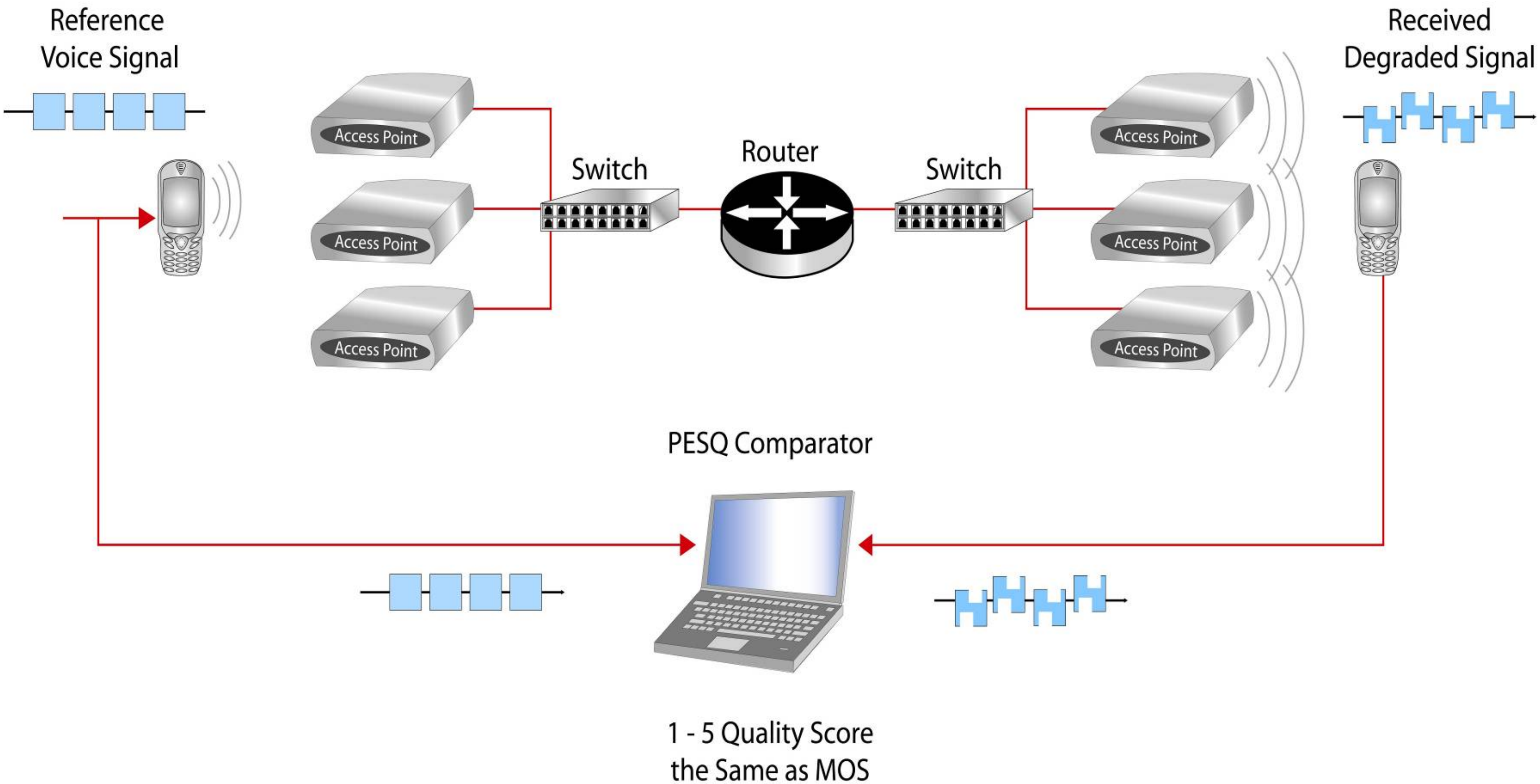
- **ITU-T: Telecommunication Standardization** is responsible for network aspects of IMT-2000, IMT-Advanced, FMC, mobility management, mobile multimedia functions, internetworking, interoperability and enhancements to existing ITU-T Recommendations.
- **ITU-R: Radiocommunications** is responsible for the radio frequency spectrum and radio system aspects of IMT-2000 and IMT-Advanced.



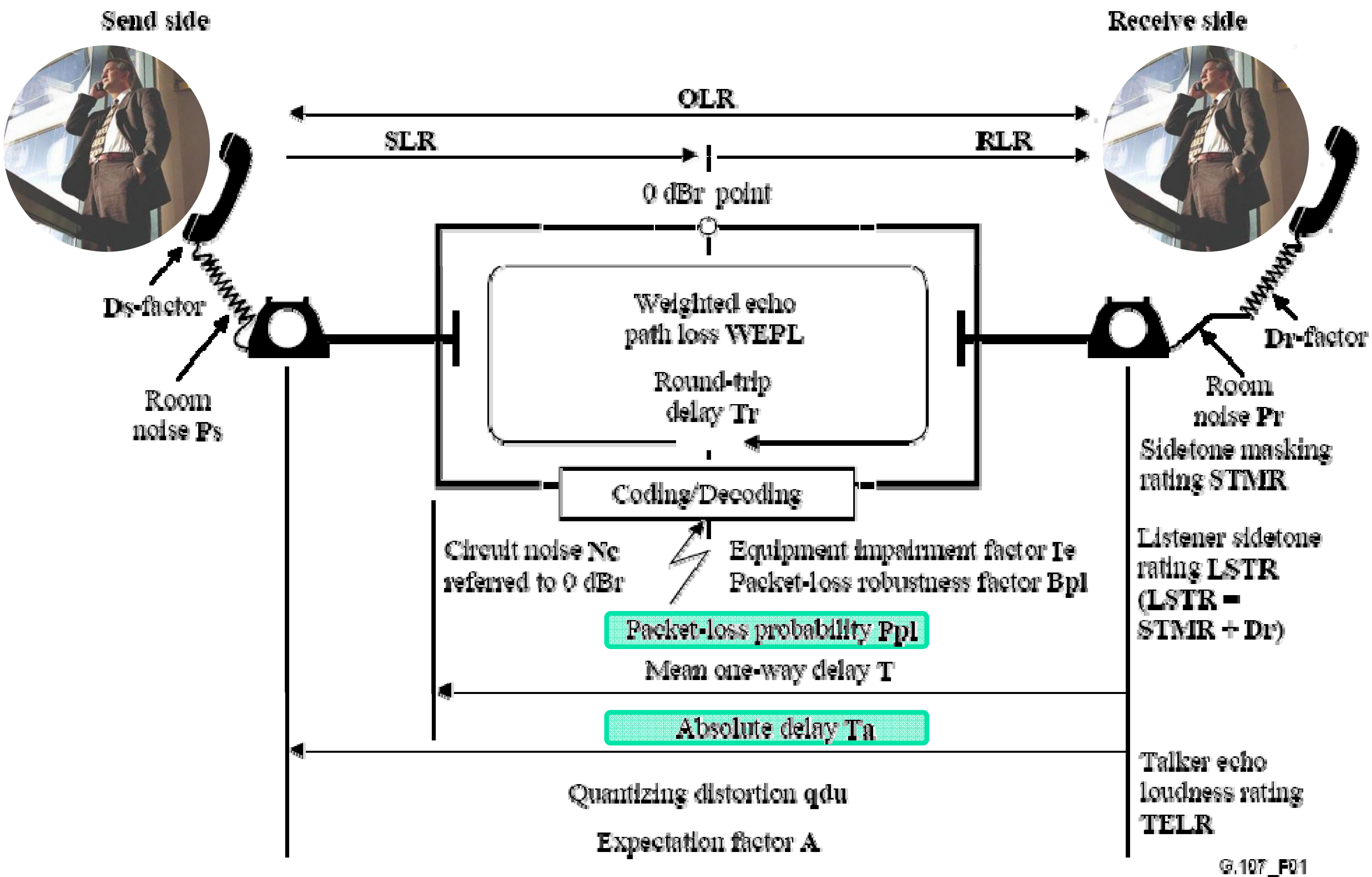
ITU-T Voice Quality Standards

- **MOS (mean opinion score)** uses a wide range of human subjects to provide a subjective quality score (ITU-T P.800)
- **PESQ (perceptual speech quality measure)** sends a voice pattern across a network and then compares received pattern to the original pattern and computes the quality rating (ITU-T P.862)
- **R-Factor (Rating factor)** computed based on delay packet loss and other network performance parameters; R-Factor directly translates into MOS (ITU-T G.107)

ITU-T PESQ Model



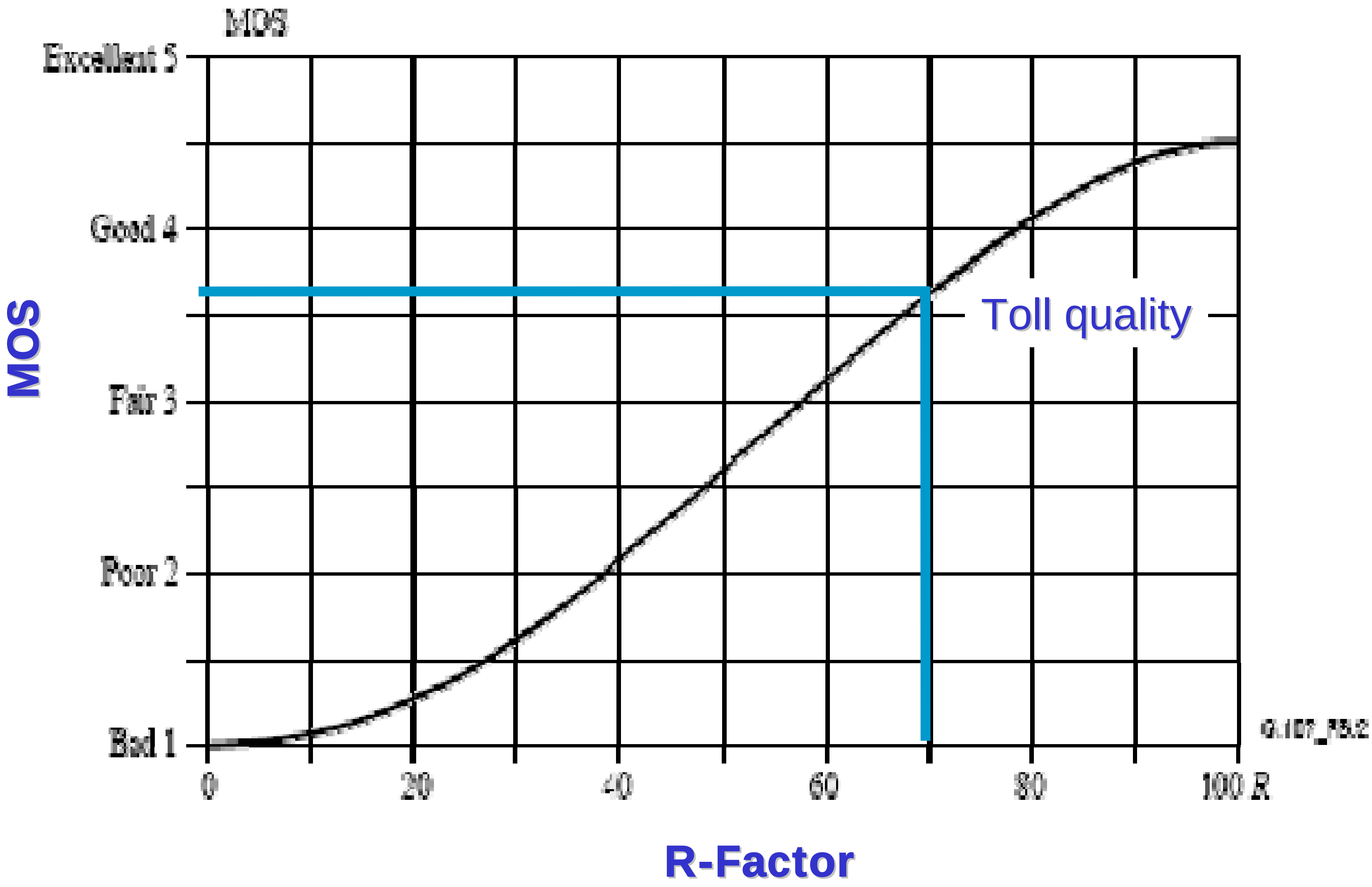
ITU-T E-Model (G.107) for Computing R-Factor



G.107 – Default values and permitted ranges for the E-model parameters

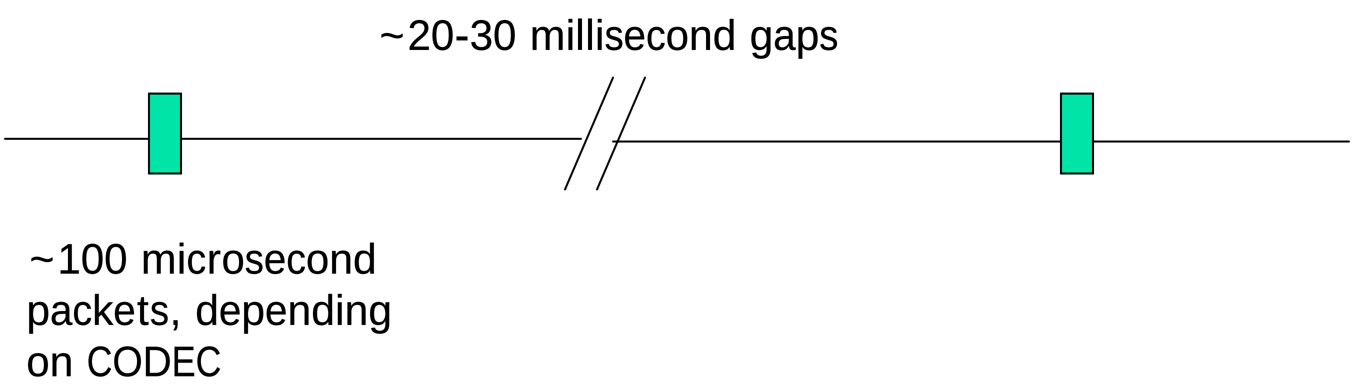
Parameter	Abbr.	Unit	Default Value	Permitted Range
Send Loudness Rating	SLR	dB	+8	0 … +18
Receive Loudness Rating	RLR	dB	+2	-5 … +14
Sidetone Masking Rating	STMR	dB	15	10 … 20
Listener Sidetone Rating	LSTR	dB	18	13 … 23
D-Value of Telephone, Send Side	Ds	-	3	-3 … +3
D-Value of Telephone Receive Side	Dr	-	3	-3 … +3
Talker Echo Loudness Rating	TELR	dB	65	5 …65
Weighted Echo Path Loss	WEPL	dB	110	5 ... 110
Mean one-way Delay of the Echo Path	T	ms	0	0 … 500
Round-Trip Delay in a 4-wire Loop	Tr	ms	0	0 … 1000
Absolute Delay in echo-free Connections	Ta	ms	0	0 … 500
Number of Quantization Distortion Units	qdu	-	1	1 … 14
Equipment Impairment Factor	Ie	-	0	0 … 40
Packet-loss Robustness Factor	Bpl	-	1	1 … 40
Random Packet-loss Probability	Ppl	%	0	0 … 20
Circuit Noise referred to 0 dBr-point	Nc	dBmOp	-70	-80 … -40
Noise Floor at the Receive Side	Nfor	dBmp	-64	-
Room Noise at the Send Side	Ps	dB(A)	35	35 … 85
Room Noise at the Receive Side	Pr	dB(A)	35	35 … 85
Advantage Factor	A	-	0	0 … 20

R-Factor to MOS Conversion



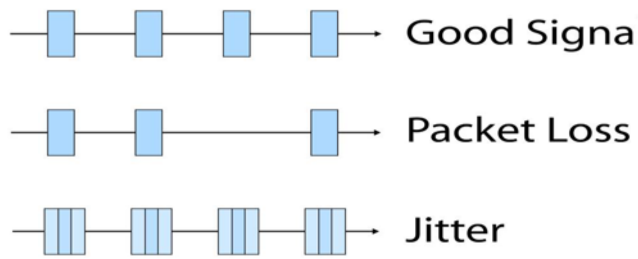
Packet Loss Consideration

- Packet loss, especially bursty packet loss, causes poor signal quality
- Delay and jitter (variation in delay) can also cause loss of quality
- 200 ms events (signal loss or delay) are audible to the ear
- In 802.11 networks, bursty packet loss can be due to
  - Congestion in the infrastructure
  - Client roaming from one AP to another



IEEE 802.11 Specifications Enabling Voice over Wi-Fi

- Minimize bursty packet loss by controlling roaming time
  - 802.11r Fast Roaming
  - 802.11k Radio Resource Measurement (RRM)
  - 802.11v Wireless Network Management
- Manage power consumption
  - 802.11 APSD (automatic power save delivery)
  - 802.11n PSMP (power save multi-poll) protocol
  - 802.11v sleep mode
- Maintain isochronous nature of voice packet streams by controlling delay, jitter and packet loss
  - WFA WMM (wireless multi-media) prioritization protocol, IEEE QSE SG (QoS Extensions Study Group) looking to reconcile IEEE 802.11 with WMM



QoS – Contention vs. Scheduled Access in 802.11

- Scheduled access introduces complexities and most vendors have opted for simpler contention based access
- Scheduled access
  - PCF (point coordination function) – contention free access based on polling
  - HCF (hybrid coordination function) encompasses PCF
  - HCCA (HCF controlled channel access) – resource reservation prioritization

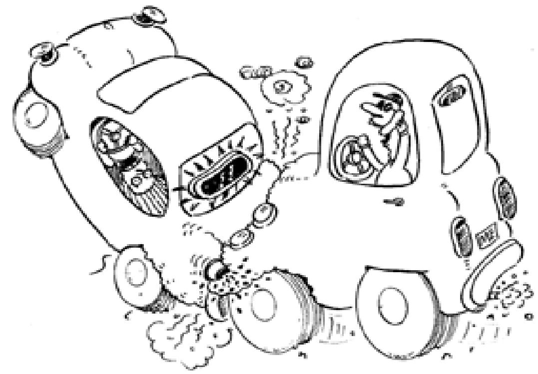
Rarely seen in products

- Contention based access (CSMA/CA)
  - DCF (distributed coordination function)
  - EDCA (enhanced distributed channel access) – traffic classification based prioritization
  - Wi-Fi Alliance WMM (wireless multimedia) prioritization

Common

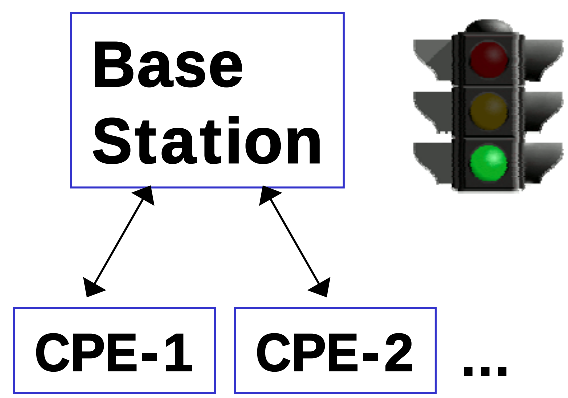
802.16 vs. 802.11 QoS

- While 802.11 settled on contention based access, 802.16 was designed for scheduled access from ground up
- 802.16 adapted DOCSIS (data over cable service interface specification) protocol for Medium Access Control (MAC) layer
  - All CPEs (customer premises equipment) locked to headend or base station
  - Scheduled access
- 802.16 scheduled access approach now poses difficulties for operation in the new contention based 3650-3700 MHz band



802.11 – contention based

802.16 – scheduled access



802.16 and WiMAX Certification

IEEE 802.16d-2004
Fixed
Broadband Wireless

IEEE 802.16e-2005
Mobile
Broadband Wireless

Mobile WiMAX
System Profile
Release-1

- WiMAX Forum Release-1
  - Based on 802.16e-2005
  - 1.25, 5, 7, 8.75, 10 and 20 MHz channels
  - Initial profiles are 5 and 10 MHz
  - Licensed worldwide spectrum allocations include 2.3, 2.5, 3.3 and 3.5 GHz bands
- The IEEE 802.16e-2005 Wireless MAN standard is based on the concept of scalable OFDMA* (S-OFDMA), which provides a range of bands to accommodate available spectrum

* Orthogonal Frequency Division Multiple Access

IEEE 802.16d vs. 802.16e

	802.16d 2004	802.16e 2005
Cell radius	7 km NLOS 30 km LOS	5 km NLOS 30 km LOS
Bit Rate	Up to 10 Mbps / 3.5 MHz	Up to 15 Mbps / 5 MHz
Bandwidth	3.5, 7 MHz	5, 7, 10 MHz
Band	2.5, 3.5, 5.8 GHz	
Signaling	OFDM, 256 subcarriers	SOFDMA, 2048 subcarriers
Mobility	Fixed, nomadic	High mobility 60 km/h

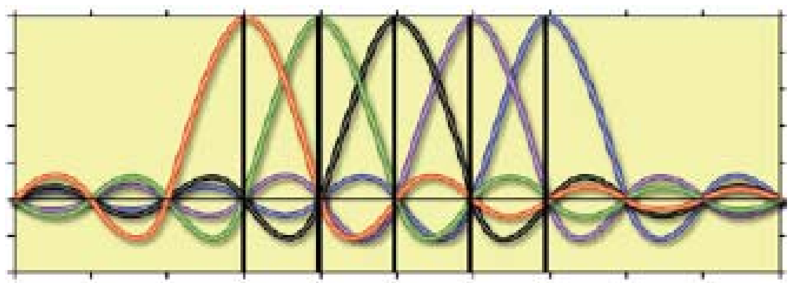
4G: LTE

- LTE (Long Term Evolution) being developed as a 4G technology competing with 802.16
  - 100 Mbps uplink; 50 Mbps downlink
  - 5 km cells; 30 km with some degradation
  - Channels 1.25, 1.6, 2.5, 5, 10, 15, 20 MHz
- MIMO-based; smart antenna
- No products yet

OFDM – Trend in Wireless Communications Technologies

- Orthogonal Frequency Division Multiplexing (OFDM) is the predominant technology for wireless data communications
  - 802.11
  - 802.16
  - 3GPP/LTE

Separate data streams on different tones
802.11 -> 52 sub-carriers
802.16d-2004 -> 256 sub-carriers
802.16e-2005 -> 2048 sub-carriers



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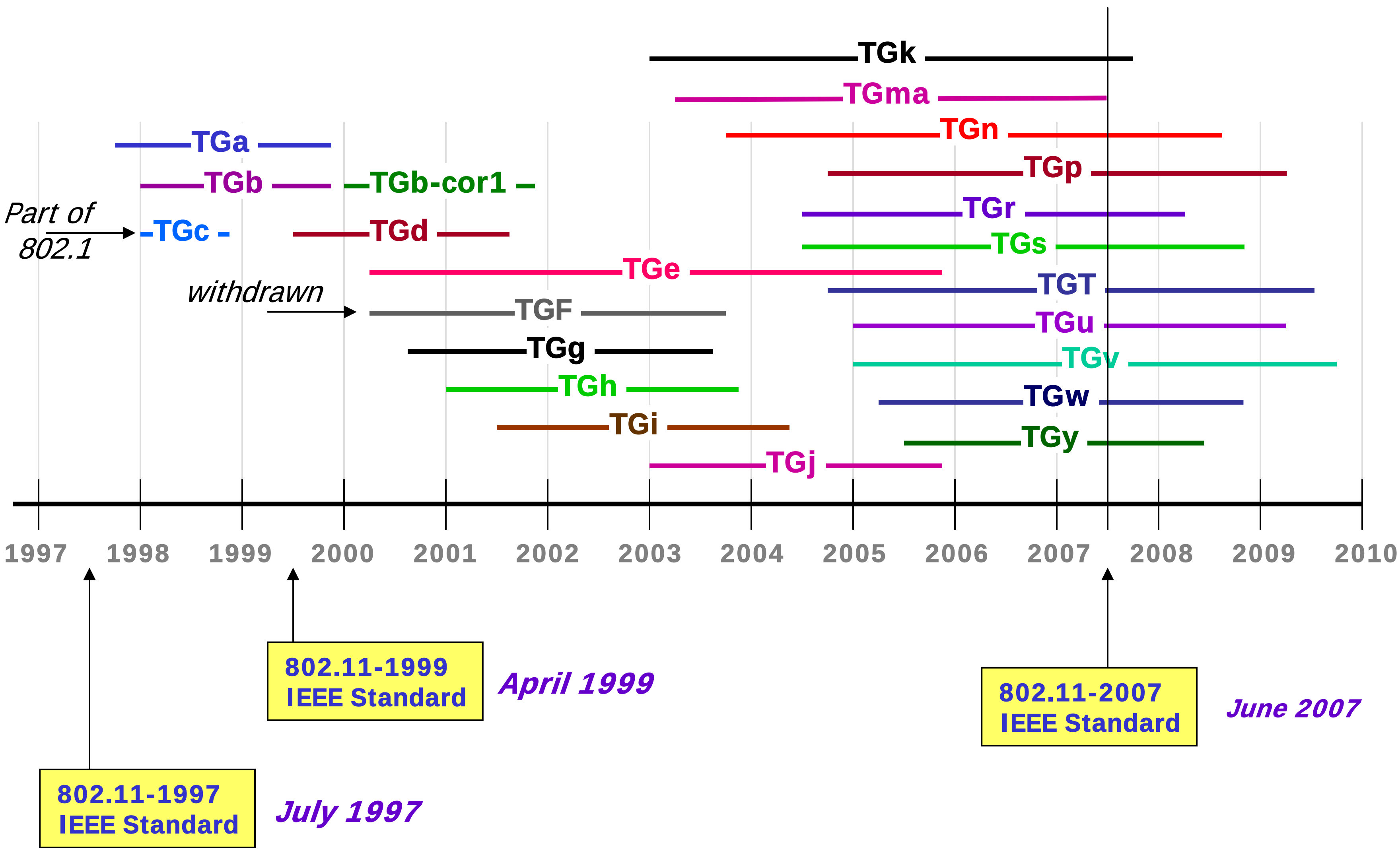
History of IEEE 802.11

- **1989**: FCC authorizes ISM (Industrial, Scientific and Medical) bands
  - 900 MHz, 2.4 GHz, 5 GHz
- **1990**: IEEE begins work on 802.11
- **1994**: 2.4 GHz products begin shipping
- **1997**: IEEE 802.11 standard approved
- **1998**: FCC authorizes the UNII (Unlicensed National Information Infrastructure) Band - 5 GHz
- **1999**: IEEE 802.11a, b ratified

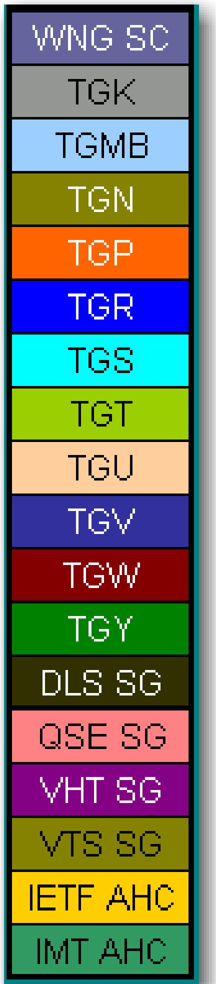
Wi-Fi Today

- Affordable to anyone at < $5 an interface
- Proliferating into consumer devices
  - Cameras
  - Phones
  - PDAs
  - Games
  - Video recorders
  - Set-top boxes
  - TV sets

IEEE 802.11 Timeline



IEEE 802.11 Active Task Groups



- **WNG SC** – Wireless Next Generation Standing Committee
- **TGk** – Radio Resource Measurements
- **TGn** – High Throughput
- **TGp** – Wireless Access Vehicular Environment (WAVE/DSRC)
- **TGr** – Fast Roaming
- **TGs** – ESS Mesh Networking
- **TGT** – IEEE 802 Performance
- **TGu** – InterWorking with External Networks
- **TGv** – Wireless Network Management
- **TGw** – Protected Management Frames
- **TGy** – 3650-3700 MHz Operation in USA
- **DLS SG** – Direct Link Setup Study Group
- **QSE SG** – QoS Extensions Study Group
- **VHT SG** – 1 Gbps Very High-Throughput Study Group
- **VTS SG** – Video Throughput Study Group
- **IETF AHC** – IETF Ad Hoc
- **IMT AHC** – IMT Ad Hoc

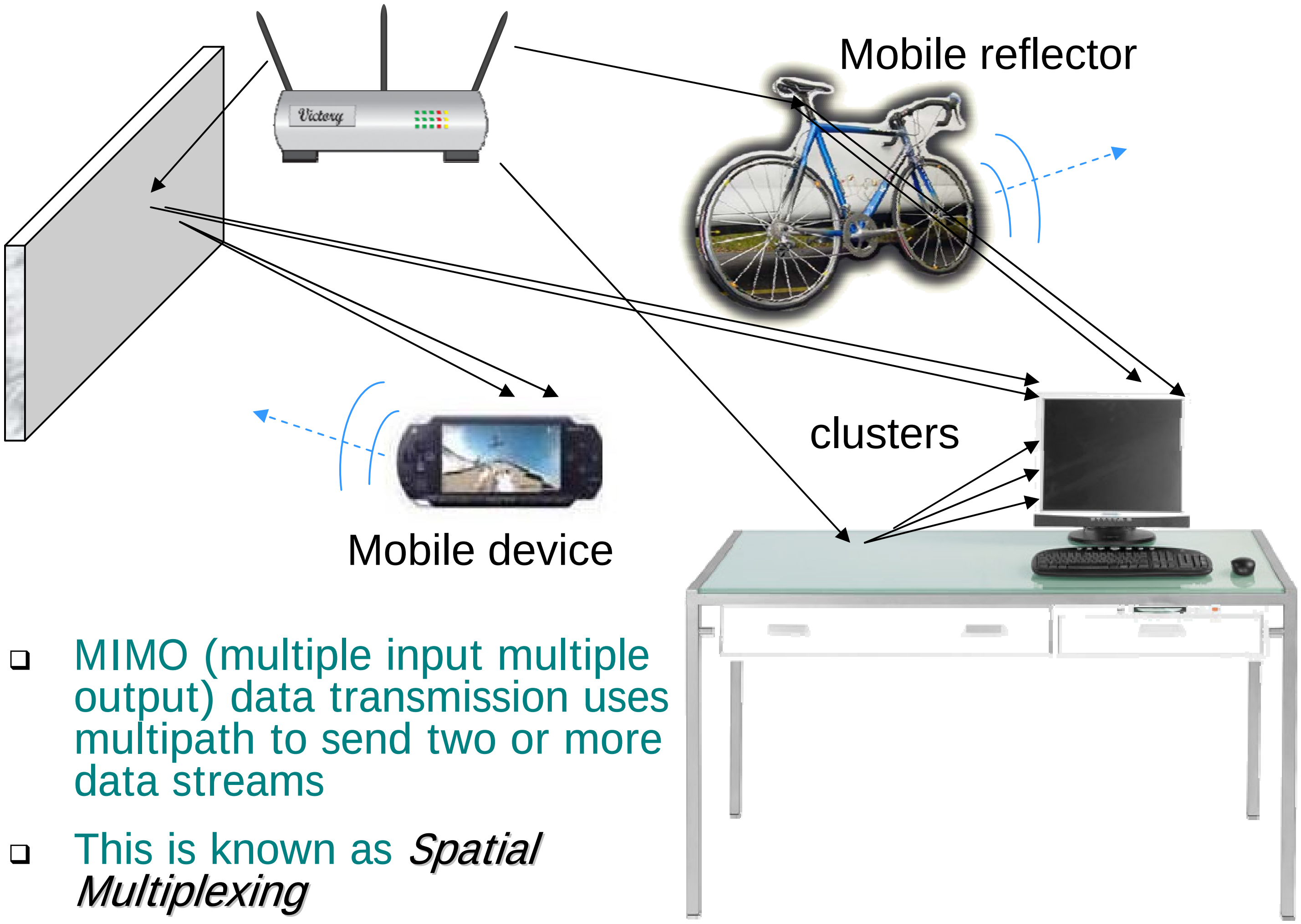
http://grouper.ieee.org/groups/802/11

IEEE 802.16 Active Task Groups

- Network Management Task Group
  - P802.16g, Management Plane Procedures & Services, Interworking
  - P802.16i, Mobile Management Information Base
  - P802.16k, 802.16 Bridging (for 802.1d)
- 802.16h, License-Exempt Task Group
  - Developing PAR (project authorization request)
  - A joint meeting next week with 802.11 TGy and 802.19
- 802.16j, Mobile Multihop Relay
  - developing PAR
- 802.16m, AMT Advanced Air Interface
  - developing PAR

http://grouper.ieee.org/groups/802/16

802.11n Uses Multipath for Spatial Multiplexing to Increase Data Rate



- MIMO (multiple input multiple output) data transmission uses multipath to send two or more data streams
- This is known as *Spatial Multiplexing*

802.11n MIMO Technology

- Goal: 100 Mbps real throughput; data rate up to 600 Mbps with 4 spatial streams in a 40 MHz channel
- PHY improvements
  - MIMO (multiple inputs multiple outputs) – Spatial Multiplexing, Beamforming, up to 4x4 MIMO, 40 MHz channels
- MAC improvements
  - Frame aggregation, block acknowledgements
- Battery life improvements for handsets
  - Sleep mode with scheduled packet delivery

Real implementations use up to 2 spatial streams and the following MIMO configurations:

2x2, 2x3, 3x3

Extra transmitters or receivers implement diversity

802.11n Throughput Enhancements

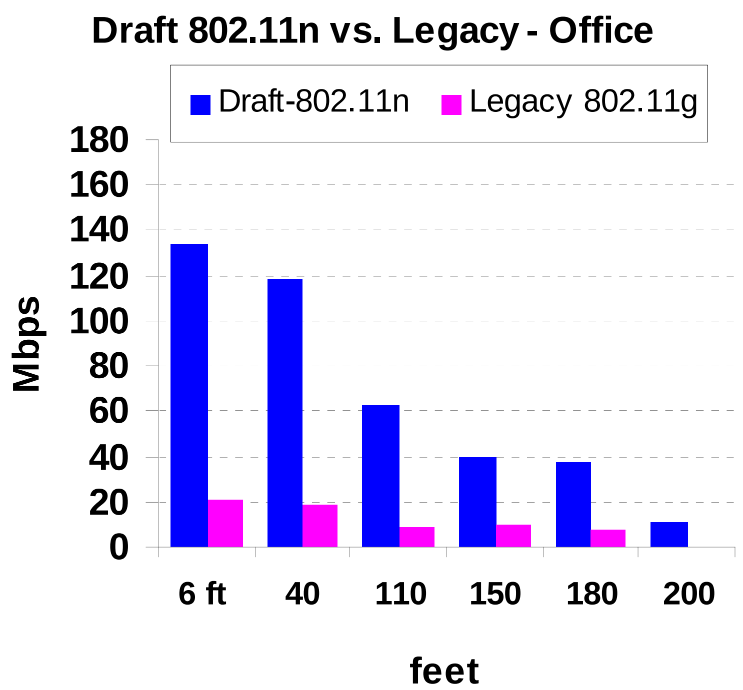
802.11n throughput enhancement	Description	Throughput enhancement over legacy
Spatial multiplexing	With 2 spatial streams throughput can be double that of a single stream.	100%
40 MHz channel width	Doubling the channel width over the legacy 20 MHz channel can double the throughput.	100%
More efficient OFDM	With 52 data sub-carriers vs. 48 for the legacy networks, the highest data rate per stream is 65 Mbps vs. the 802.11a/g 54 Mbps	20%
Shorter GI	The short GI of 400 ns allowed by 802.11n reduces the symbol time from 4 microseconds to 3.6 microseconds increasing the symbol rate by 10%.	10%
Frame aggregation and Block ACK	64k bytes A-MPDU; 8k bytes A-MSDU	Up to 100%

IEEE 802.11a,b,g,n

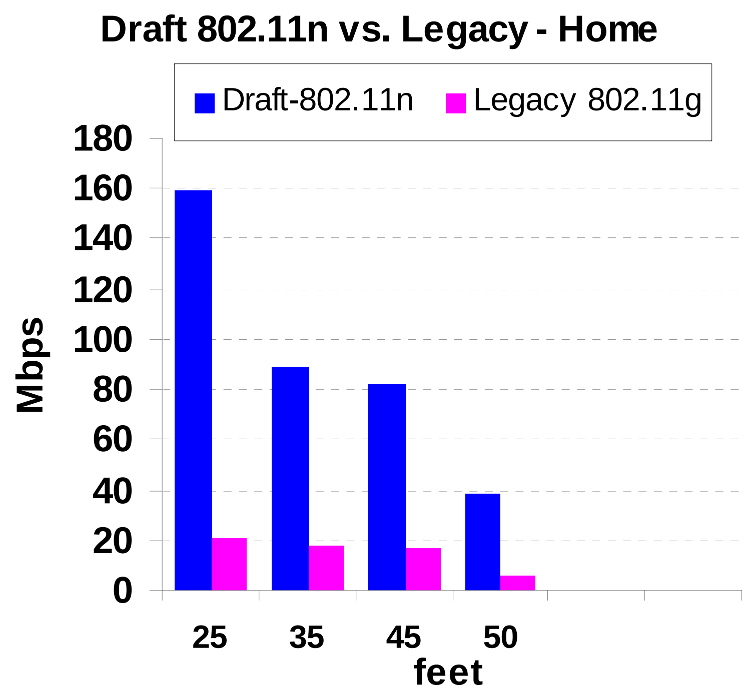
	20 MHz Channel		40 MHz Channel	
	1 stream	2 streams	1 stream	2 streams
	Data Rate, in Mbps			
802.11b 2.4 GHz	1, 2, 5.5, 11			
802.11a 5 GHz	6, 9, 12, 18, 24, 36, 48, 54			
802.11g 2.4 GHz	1, 2, 6, 9, 12, 18, 24, 36, 48, 54			
802.11n GI[1]=800ns 2.4 GHz	6.5, 13, 19.5, 26, 39, 52, 58.5, 65	13, 26, 39, 52, 78, 104, 117, 130		
802.11n GI[1]=800ns 5 GHz	6.5, 13, 19.5, 26, 39, 52, 58.5, 65	13, 26, 39, 52, 78, 104, 117, 130	13.5, 27, 40.5, 54, 81, 108, 121.5, 135	27, 54, 81, 108, 162, 216, 243, 270
802.11n, GI=400ns 2.4 and 5 GHz	7.2, 14.4, 21.7, 28.9, 43.3, 57.8, 65, 72.2	14.4, 28.9, 43.3, 57.8, 86.7, 115.6, 130, 144.4	15, 30, 45, 60, 90, 120, 135, 150	30, 60, 90, 120, 180, 240, 270, **300**

[1] GI = Guard Interval, period within an OFDM symbol allocated to letting the signal settle prior to transmitting the next symbol. Legacy 802.11a/b/g devices use 800ns GI. GI of 400ns is optional for 802.11n.

Draft 802.11n vs. Legacy Throughput Performance



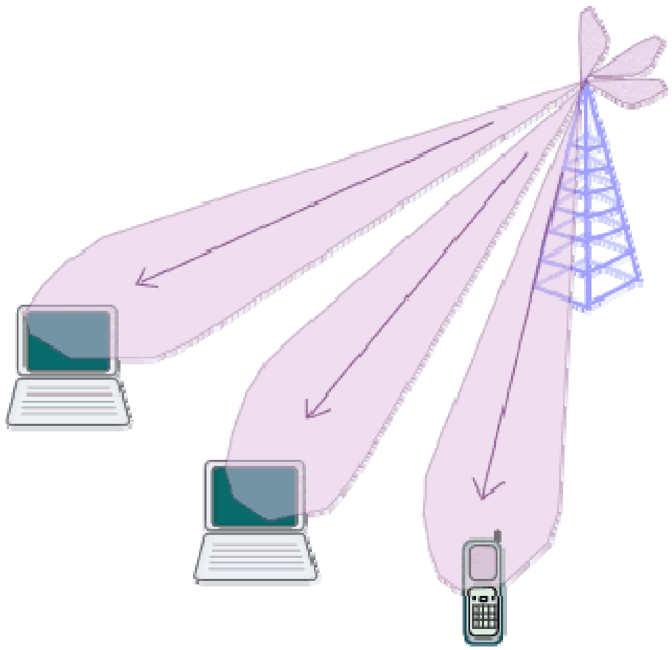
Vendor 1



Vendor 2

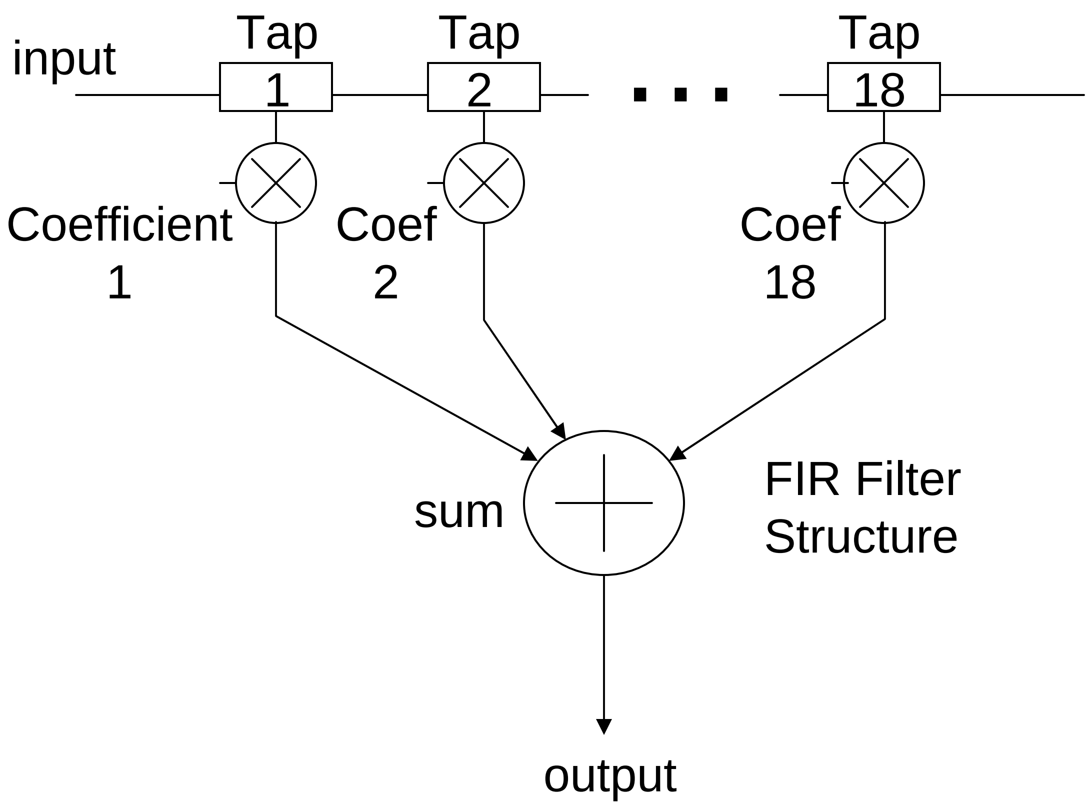
Smart Antenna Technologies for 802.11 and 802.16

- **Spatial Multiplexing**
  - Multiple streams are transmitted over multiple antennas
  - Multi-antenna receivers separate the streams to achieve higher throughput
  - In uplink single-antenna stations can transmit simultaneously
- **Beamforming**
  - Use multiple-antennas to spatially shape the beam to improve coverage and capacity



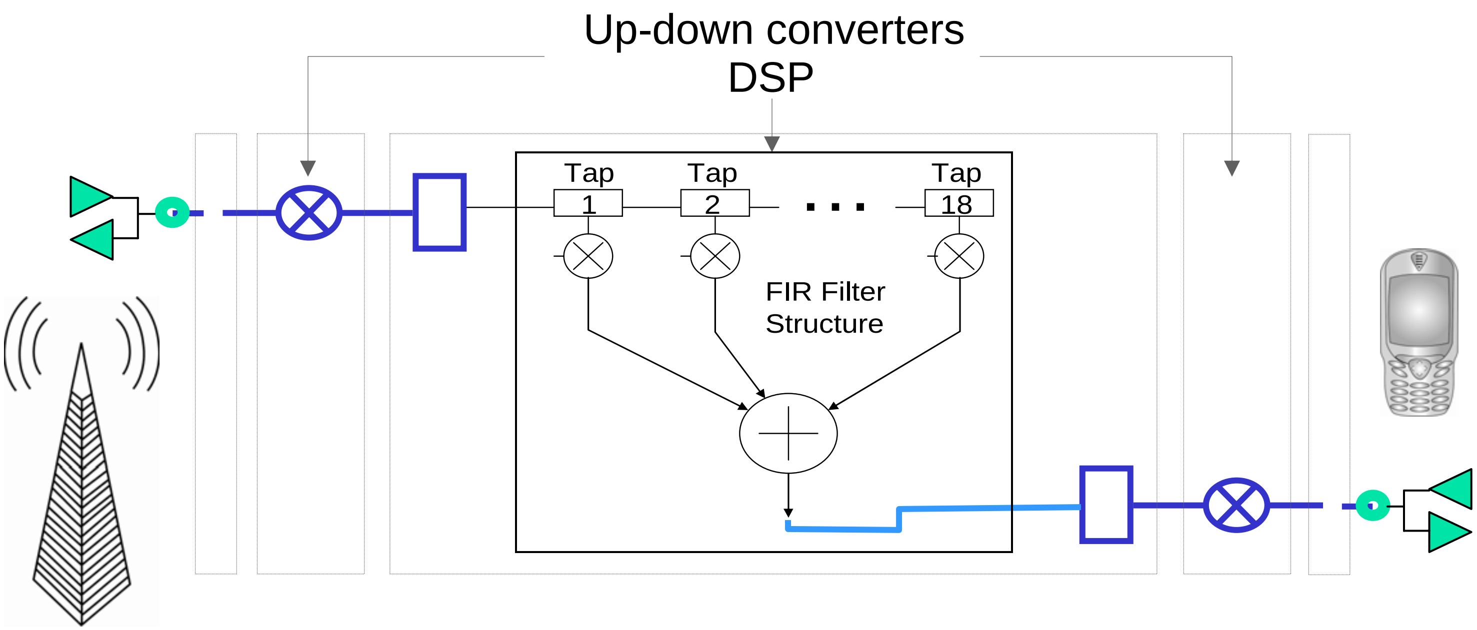
2x2 MIMO spatial multiplexing can double data rate by transmitting two data streams simultaneously

Multipath Channel Model



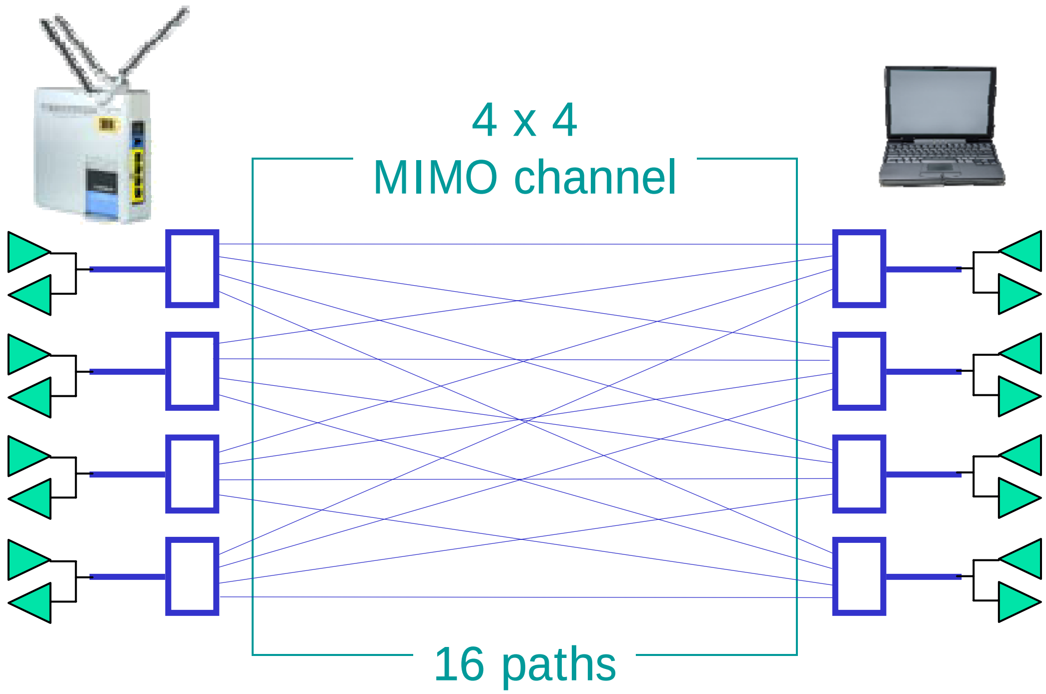
- Multipath channel model is analogous to a Finite Impulse Response (FIR) filter with taps modeling delays and coefficients modeling the strength of reflections from each delay

Single Path Channel Emulator



- Traditional single path channel emulator for SISO (single input single output) wireless channel

MIMO Channel Model



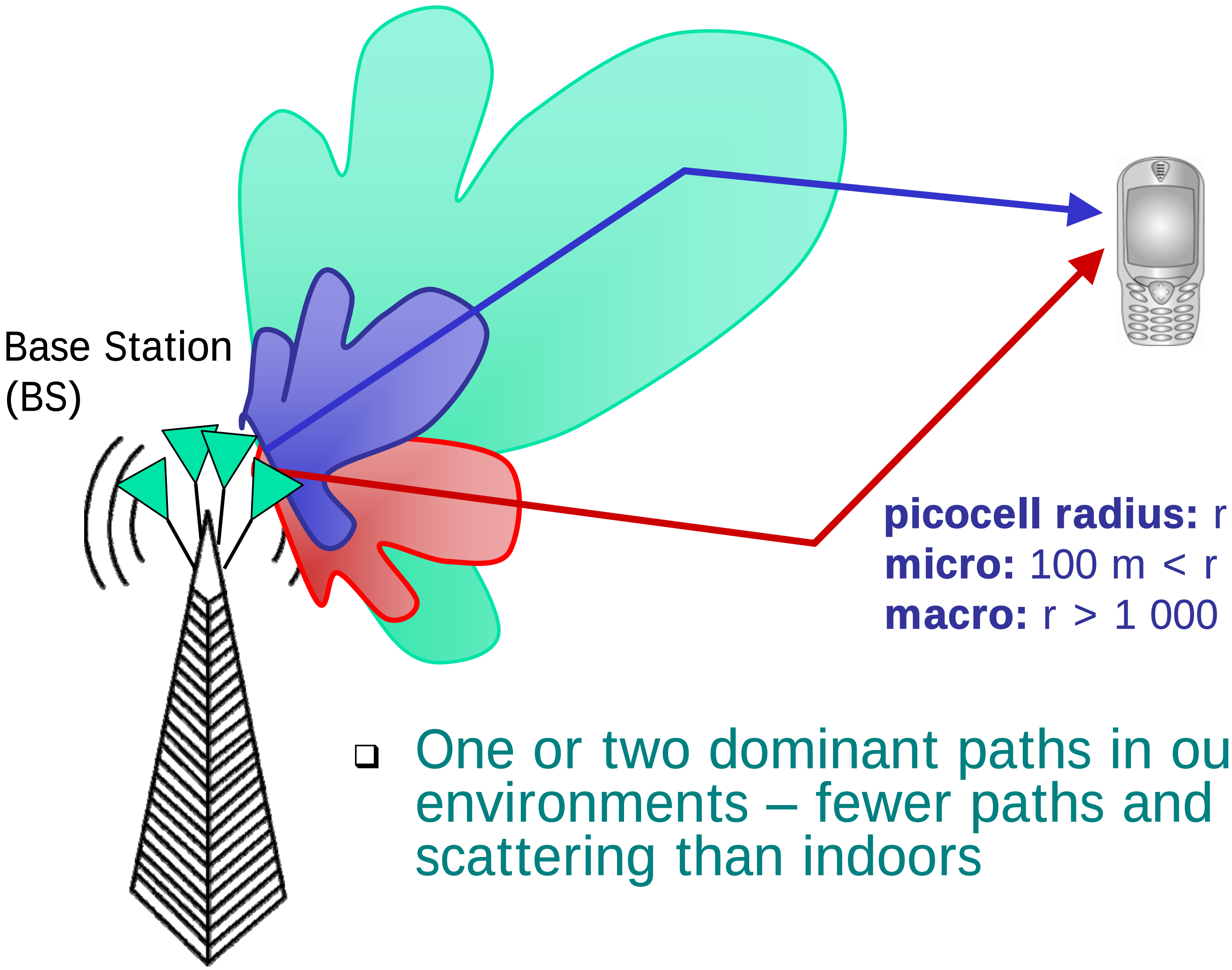
- N times M signal paths through the channel, where N is the number of transmitters and M is the number of receivers

802.11n Channel Models

Parameters	Models A	B	C	D	E	F
Avg 1st Wall Distance (m)	5	5	5	10	20	30
RMS Delay Spread (ns)	0	15	30	50	100	150
Maximum Delay (ns)	0	80	200	390	730	1050
Number of Taps	1	9	14	18	18	18
Number of Clusters	N/A	2	2	3	4	6

- Delay spread is a function of the size of the modeled environment
- Number of clusters represents number of independent propagation paths modeled
- Doppler spectrum assumes reflectors moving in environment at 1.2 km/h, which corresponds to about 6 Hz in 5 GHz band, 3 Hz in 2.4 GHz band

Outdoor Multipath Environment



picocell radius: r < 100 m
micro: 100 m < r < 1 000 m
macro: r > 1 000 m

- One or two dominant paths in outdoor environments – fewer paths and less scattering than indoors

WiMAX MIMO Channel Models

WiMAX system performance simulations [3,4,5] are based on ITU models

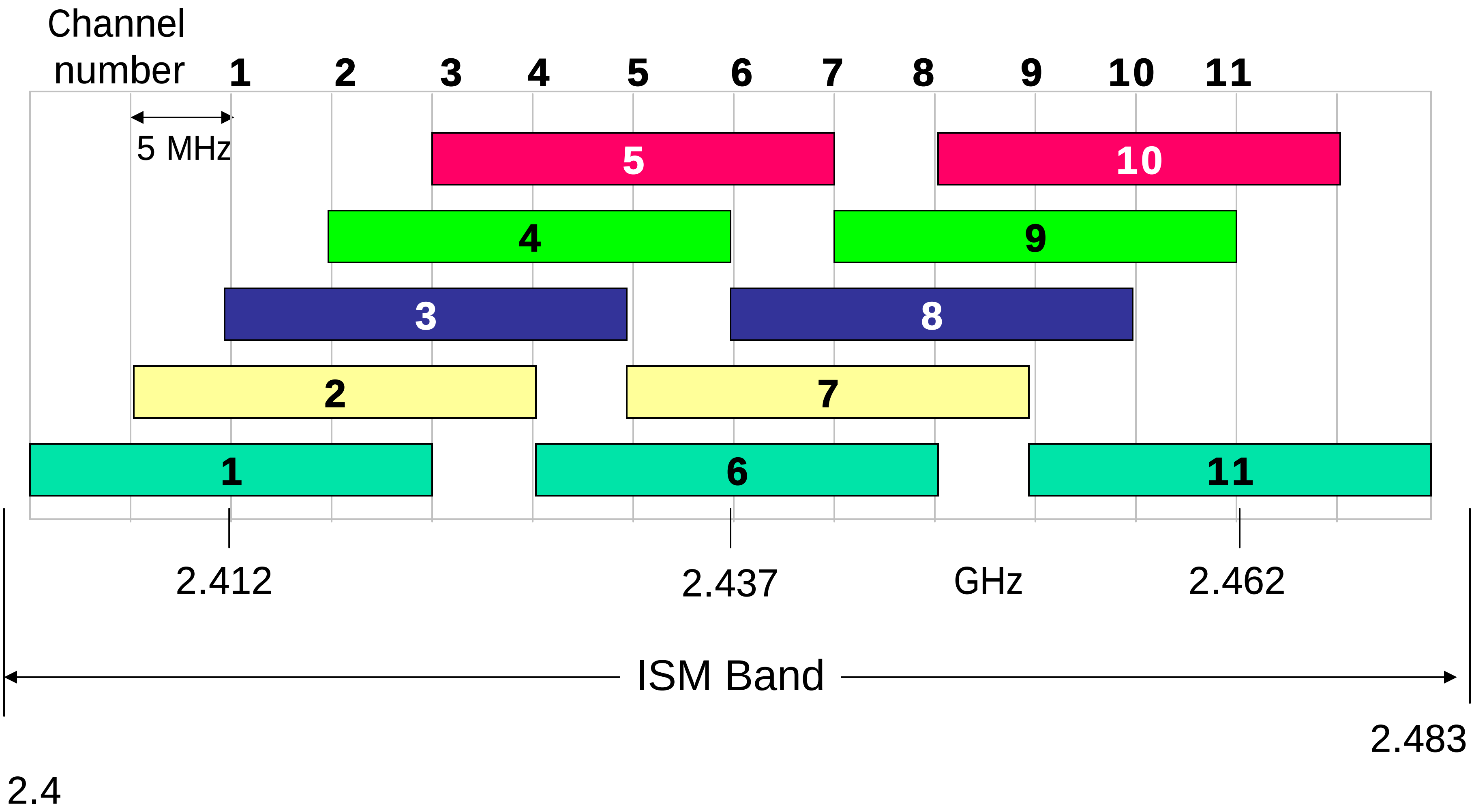
Channel Model	Path 1	Path 2	Path 3	Path 4	Path 5	Path 6
ITU Pedestrian B (relative figures)	0 dB 0 ns	-0.9 dB 200 ns	-4.9 dB 800 ns	-8.0 dB 1200 ns	-7.8 dB 2300 ns	-23.9 dB 3700 ns
ITU Vehicular A (relative figures)	0 dB 0 ns	-1.0 dB 310 ns	-9.0 dB 710 ns	-10.0 dB 1090 ns	-15.0 dB 1730 ns	-20.0 dB 2510 ns

Channel Model	Speed	Probability
ITU Pedestrian B	3 km/hr	60%
ITU Vehicular A	30 km/hr	30%
	120 km/hr	10%

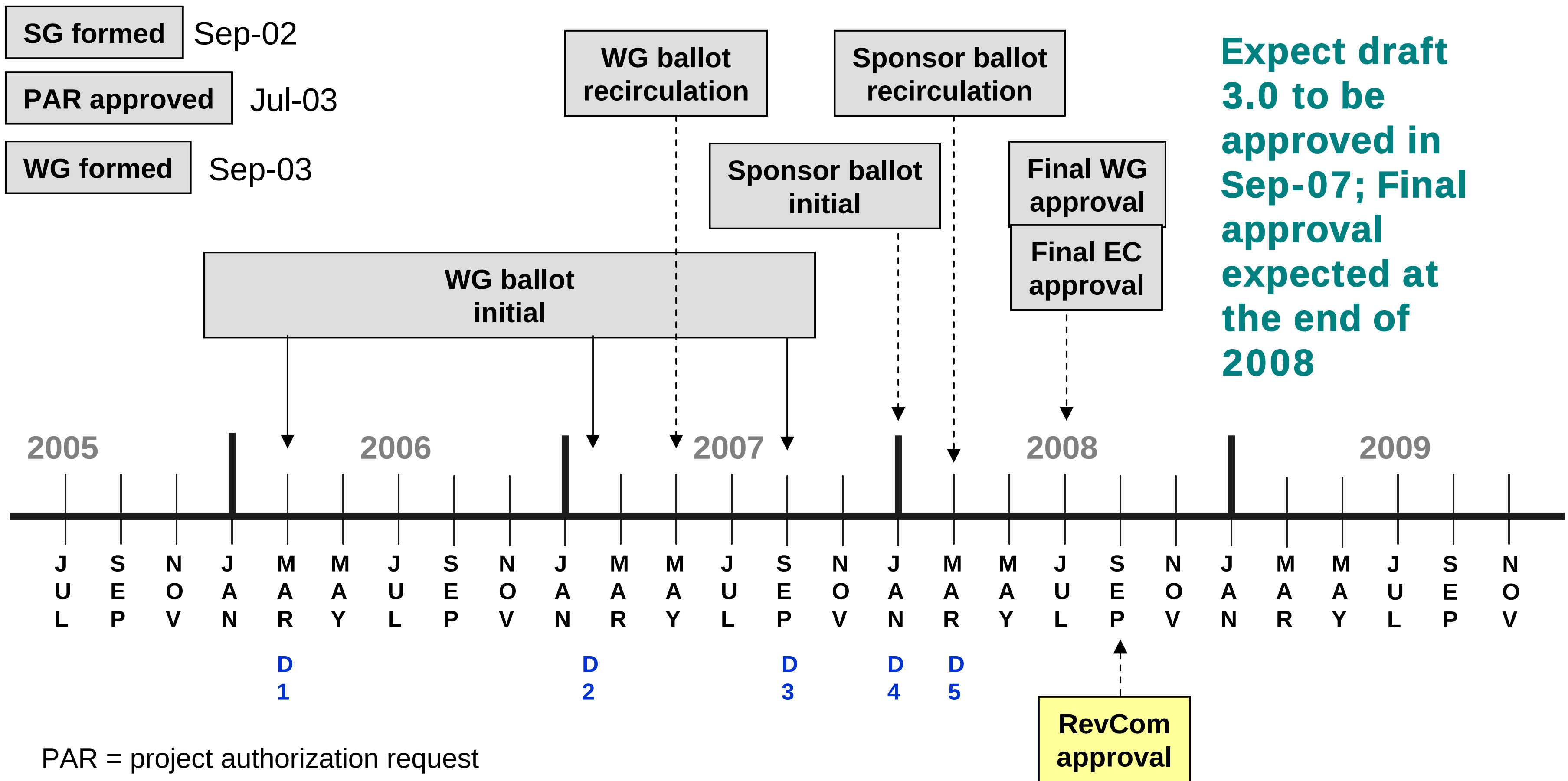
802.11n 40 MHz Channels in the 2.4 GHz Band

- Potential for interference with legacy networks crowding in the ISM band
- Detection of interfering networks is difficult due for 11 possible overlapping channels
- CCA (clear channel assessment) has to be performed on each overlapping channel periodically to ensure that 802.11n doesn't interfere with adjacent 802.11 networks
- The TGn is evaluating schemes for coordinated channel scanning by multiple stations in the 802.11n BSS (basic service set)
- 40 MHz operation is not an issue in the 5GHz band where channels are spaced every 20 MHz

2.4 GHz Channels



802.11n Timeline



Expect draft 3.0 to be approved in Sep-07; Final approval expected at the end of 2008

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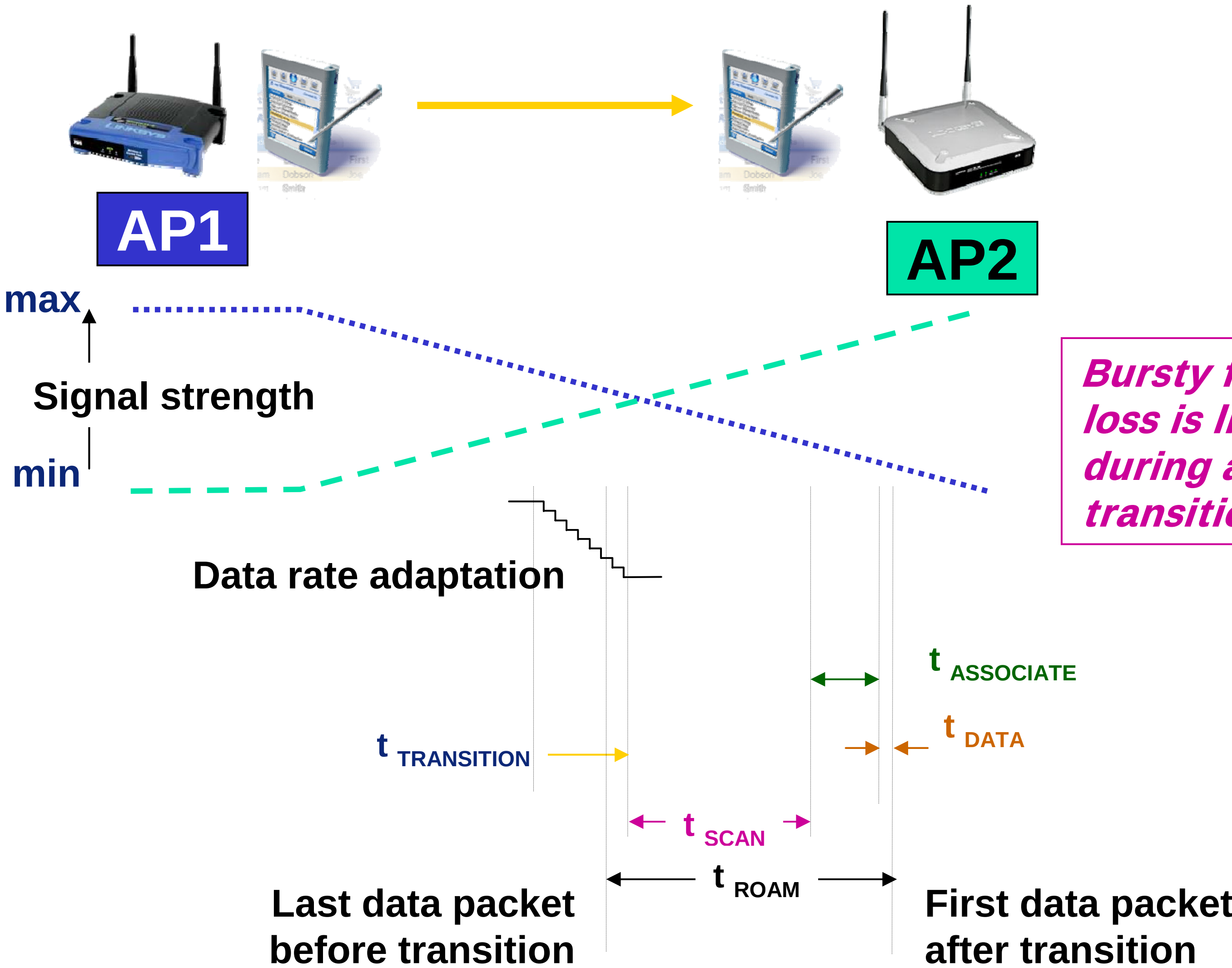
TGn timeline

802.11r Fast Transition (Roaming)

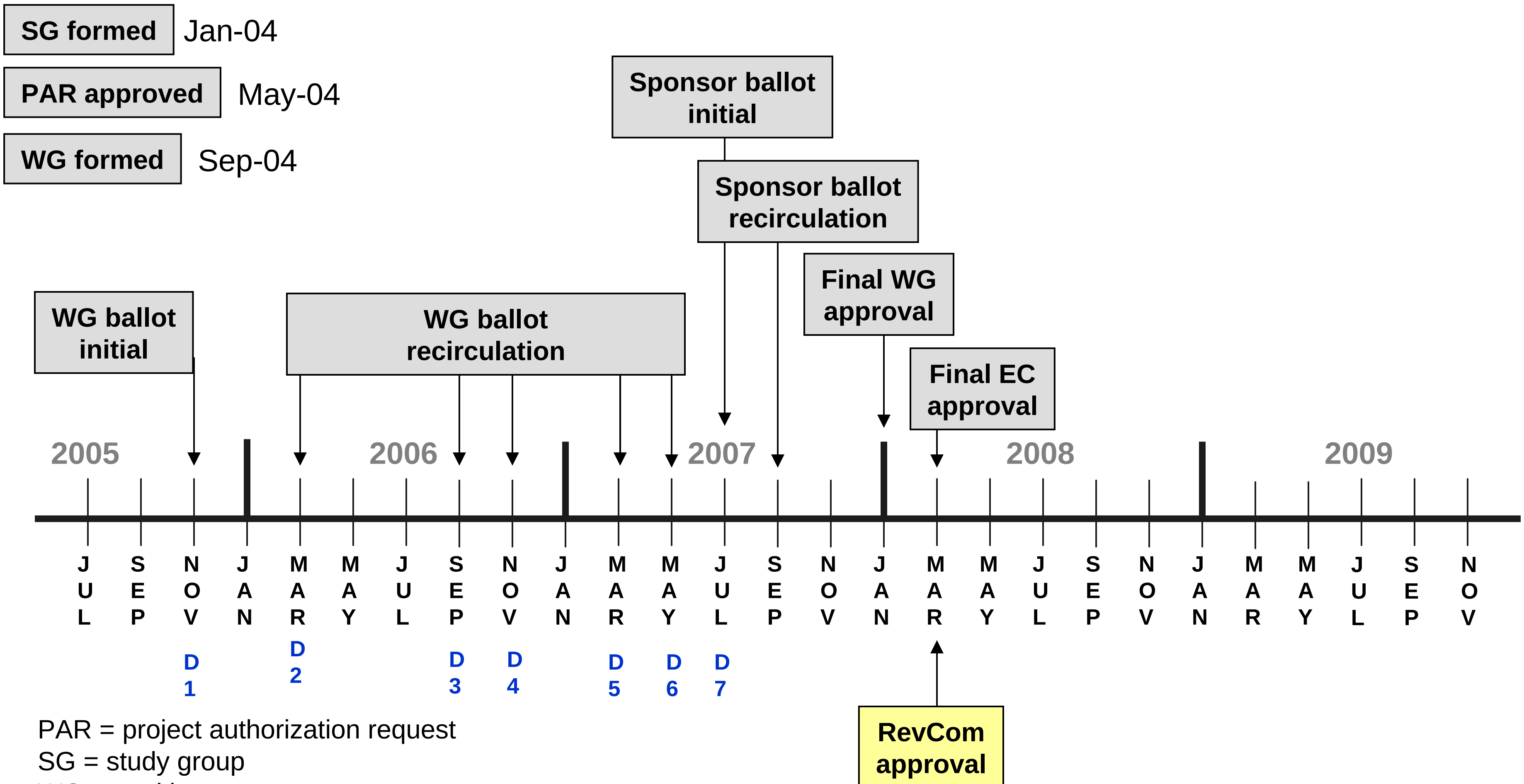
- Needed by voice applications
- Basic methodology involves propagating authentication information for connected stations through the 'mobility domain' to eliminate the need for re-authentication upon station transition from one AP to another
- The station preparing the roam can setup the target AP to minimize the actual transition time
- Roaming from one mobility domain to another requires authentication and is not considered fast transition

Traditional Roaming in 802.11



Bursty frame loss is likely during a transition

802.11r Timeline



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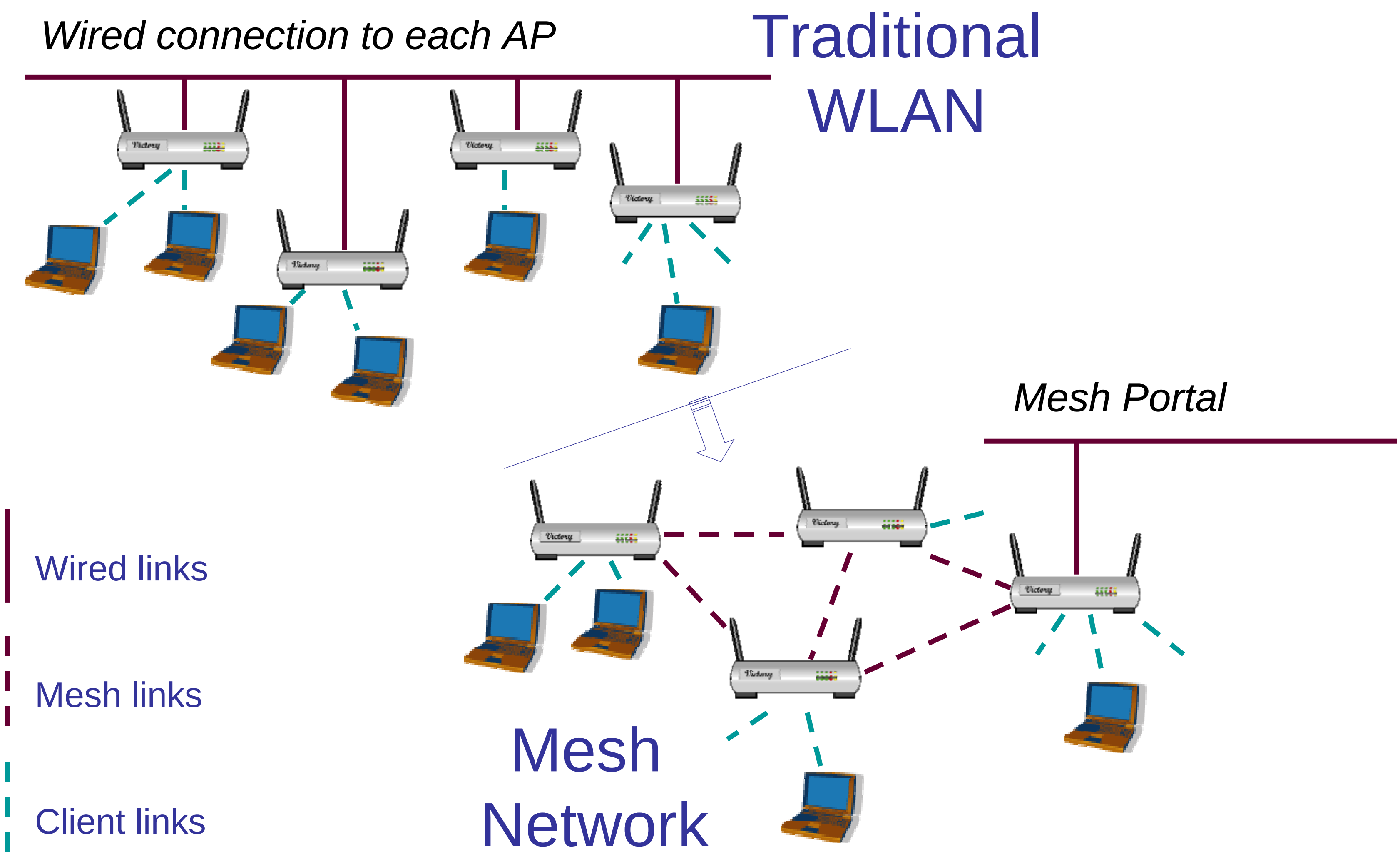
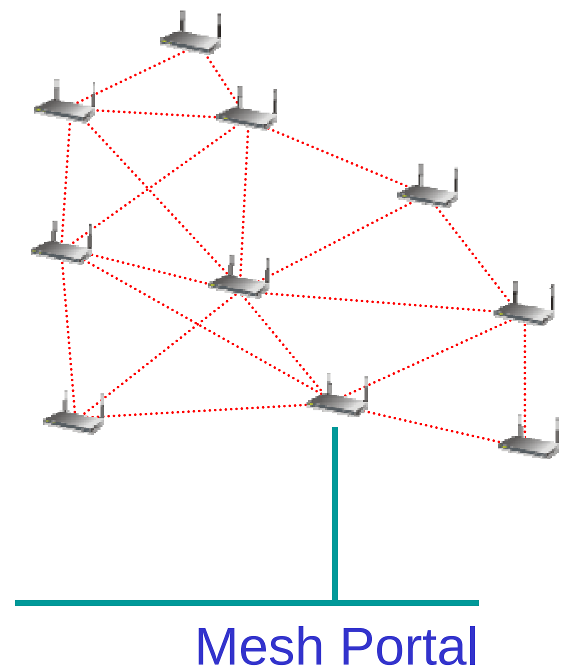
TGr timeline

802.11s Wi-Fi Mesh



IEEE 802.11s Mesh Standard

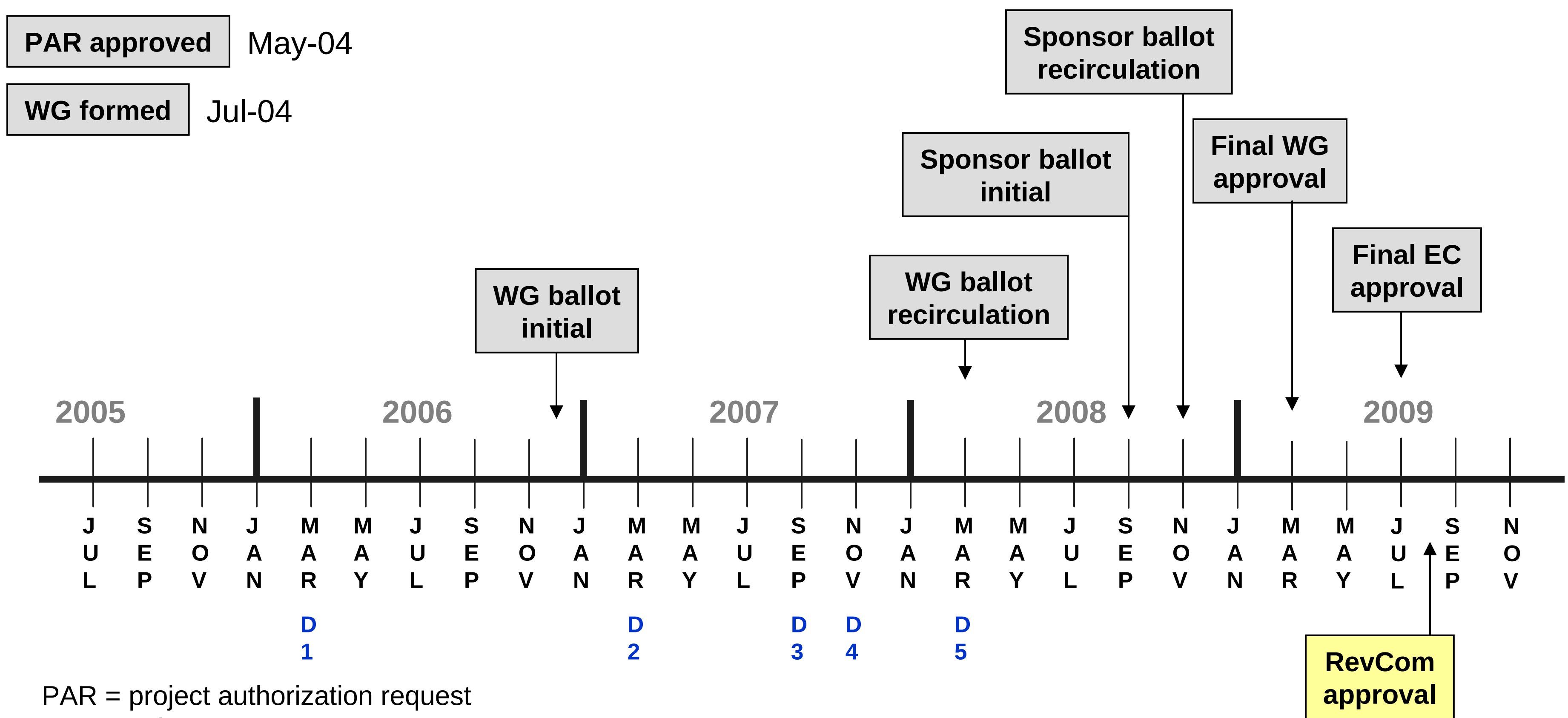
- Wireless Distribution System with automatic topology learning and wireless path configuration
- Self-forming, self-healing, dynamic routing
- ~32 nodes to make routing algorithms computationally manageable
- Extension of 802.11i security and 802.11e QoS protocol to operate in a distributed rather than centralized topology



802.11s Considerations for Voice

- To properly support VoIP, 802.11s needs to incorporate the fast handoff mechanisms defined in 802.11r.
- The goal is to enable stations to roam from one mesh AP to another within approximately 50 ms so as to introduce no noticeable degradation in a voice call.

802.11s Timeline



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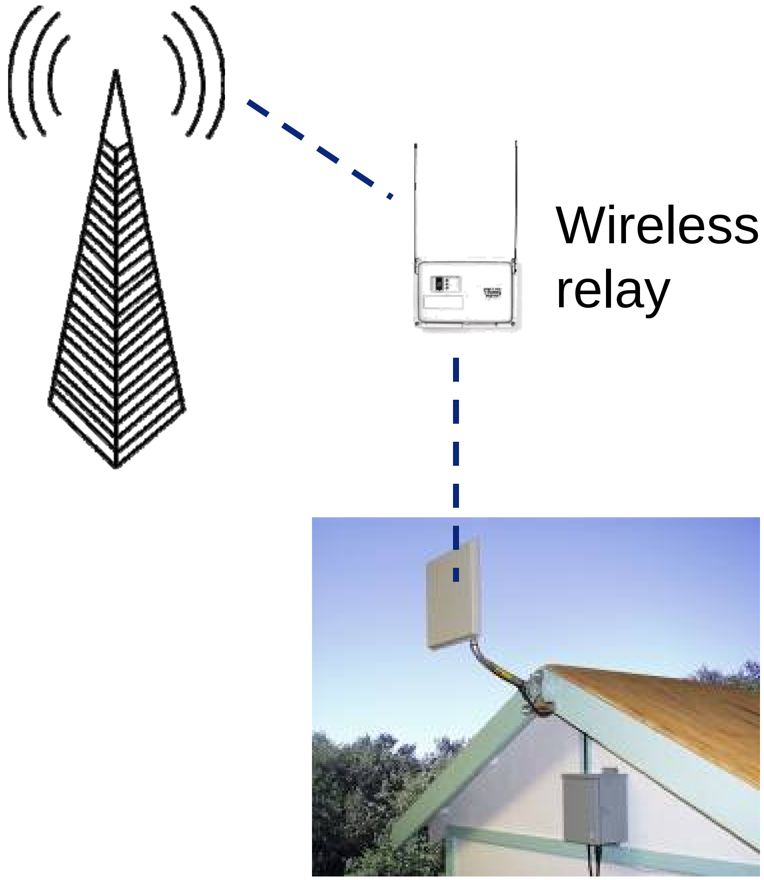
TGs timeline

IEEE 802.16 and 802.15 Mesh Standards

- 802.16j and 802.15.5 are also standardizing mesh topologies
- 802.16j is not an ad-hoc mesh, but a relay to extend the range between a CPE and a base station
- 802.16 links being planed in ad-hoc mesh networks

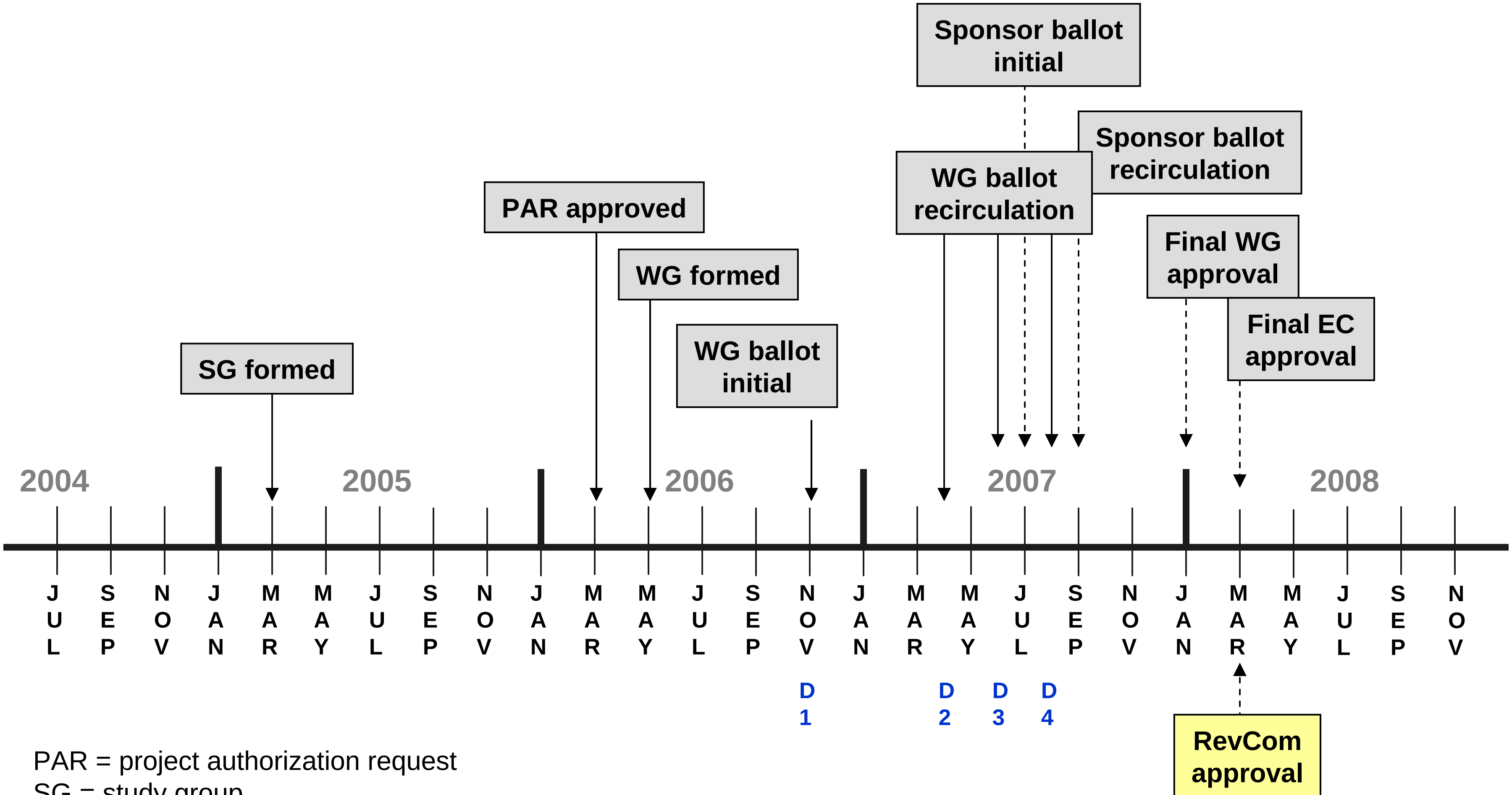


Lightly Regulated Band for 802.11, 802.16

- March 2005 FCC offered 50 MHz 3650 to 3700 MHz for *contention-based protocol*
- 802.11y meets FCC requirement; 802.16h is working to comply
- 21st century regulation geared for digital communications
  - multiple services to share the band in an orderly way

- **300 Million licenses one for every person or company**
- **$300 per license for 10 years**
- **Registered stations (base stations): 1 W/MHz, ~15 km**
- **Unregistered stations (handsets, laptops): 40 mW/MHz, 1-1.5 km**

802.11y Timeline



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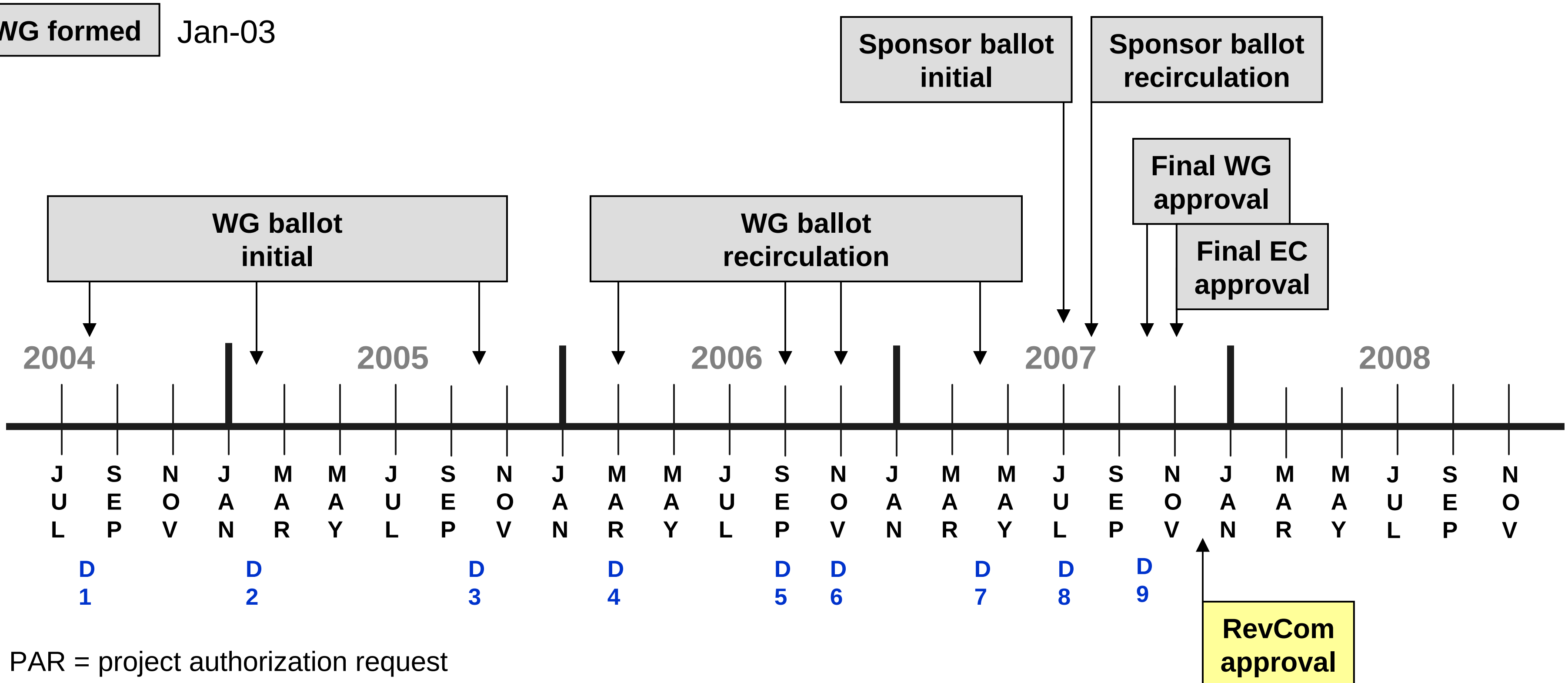
TGy timeline

802.11k Radio Resource Measurement

- Impetus for 802.11k came from the Enterprises that needed to manage their WLANs from a central point
- 802.11k makes a centralized network management system by providing layer 2 mechanisms for
  - Discovering network topology
  - Monitoring WLAN devices, their receive power levels, PHY configuration and network activity
- Can be used to assists 802.11r Fast Transition (roaming) protocol with handoff decisions based on the loading of the infrastructure, but 802.11v is more focused on load balancing

802.11k Timeline

SG formed	Sep-02
PAR approved	Dec-02, Sep-06
WG formed	Jan-03



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TGk timeline

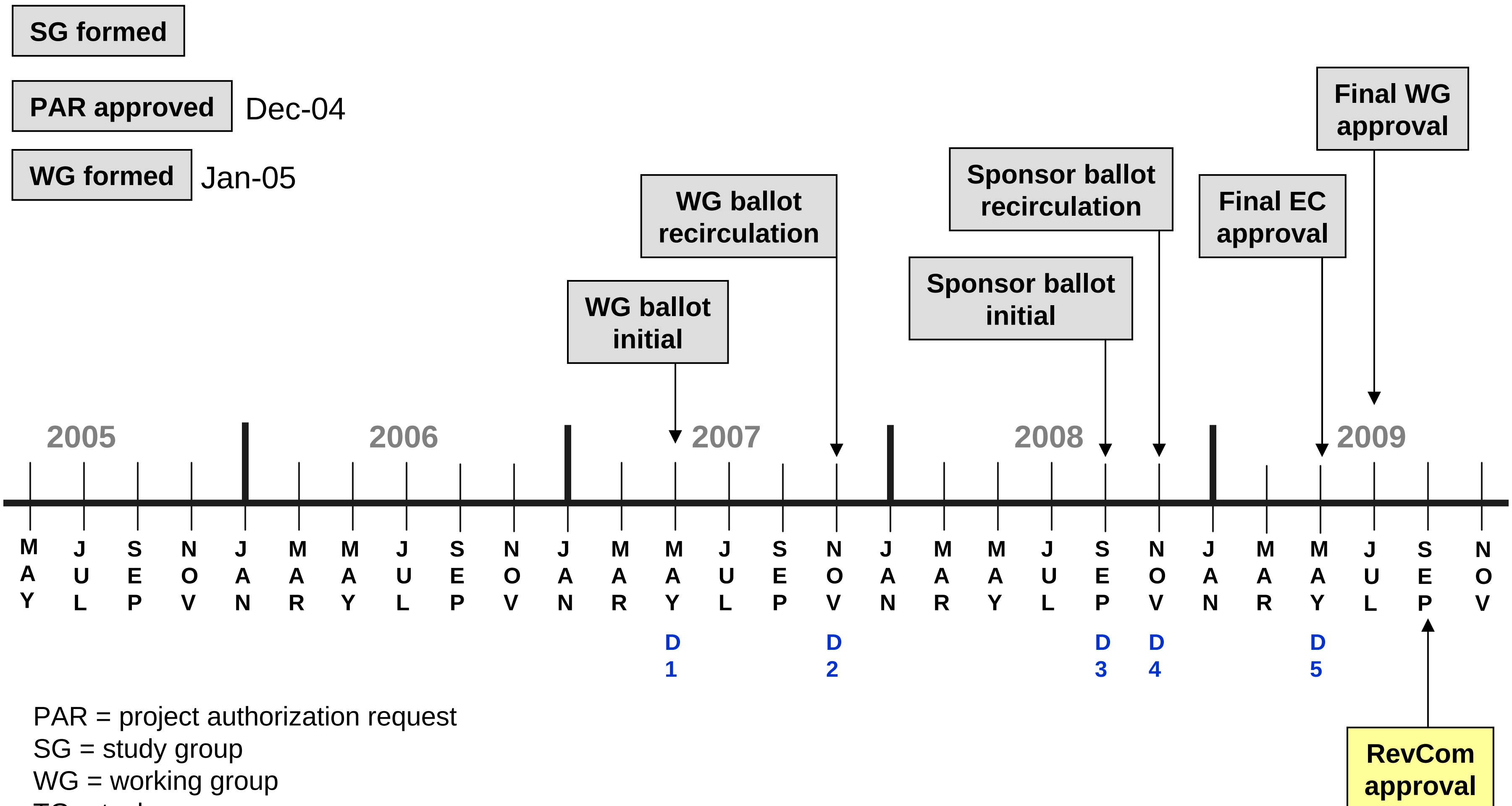
802.11v Wireless Network Management

- TGv's charter is to build on the network *measurement* mechanisms defined by TGk and introduce network *management* functions to provide Enterprises with centralized network management and load balancing capabilities.
- Major goals: **manageability, improved power efficiency** and **interference avoidance**
- Defines a protocol for requesting and reporting location capability
  - Location information may be CIVIC (street address) or GEO (longitude, latitude coordinates)
- For the handset, TGv may enable awareness of AP e911 capabilities while the handset is in sleep mode; this work has common ground with TGu

802.11v Improves Power Efficiency

- TGv defines FBMS (flexible broadcast multicast service) - the mechanism to let devices extend their sleep period
- Devices can specifying the wake up interval to be longer than a single DTIM (delivery traffic indication message). This consolidates traffic receive/transmit intervals and extends battery life of handsets.
- Sleep mode is also part of 802.11n (PSMP) and 802.11u. TGs is also dealing with power conservation and sleep mode protocol, working to make this protocol distributed whereby a mesh point registers its sleep mode with the neighbors.
- TGv may extend the sleep mode protocol to include the ability of maintaining location awareness while in sleep mode.

801.11v Timeline



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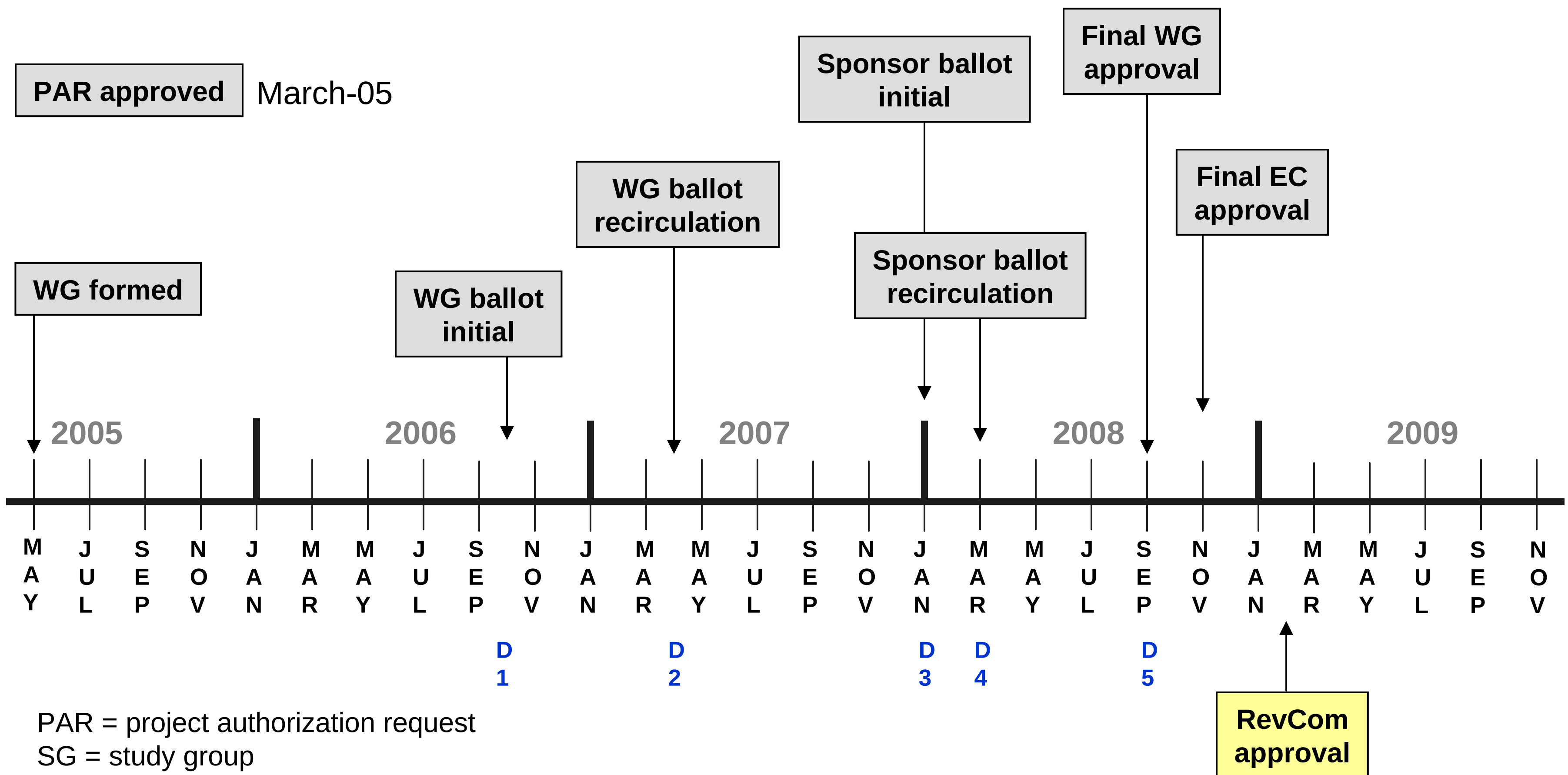
TGv timeline

802.11w Protected Management Frames

- 802.11w protects against the forgery of management frames
- 802.11k and now 802.11v are both adding new mgt frames that can exchange sensitive information
  - Information about network topology, location and loading
  - Configuration commands to optimize the network
- These frames can be easily forged by the attackers to disrupt the network
  - For example, an attacker can forge AP loading messages redirecting client associations or locking users out of the network
- TGw provides protection for the management frames after association and after keys have been set up through 802.11i or 802.11r mechanisms.

802.11w Timeline



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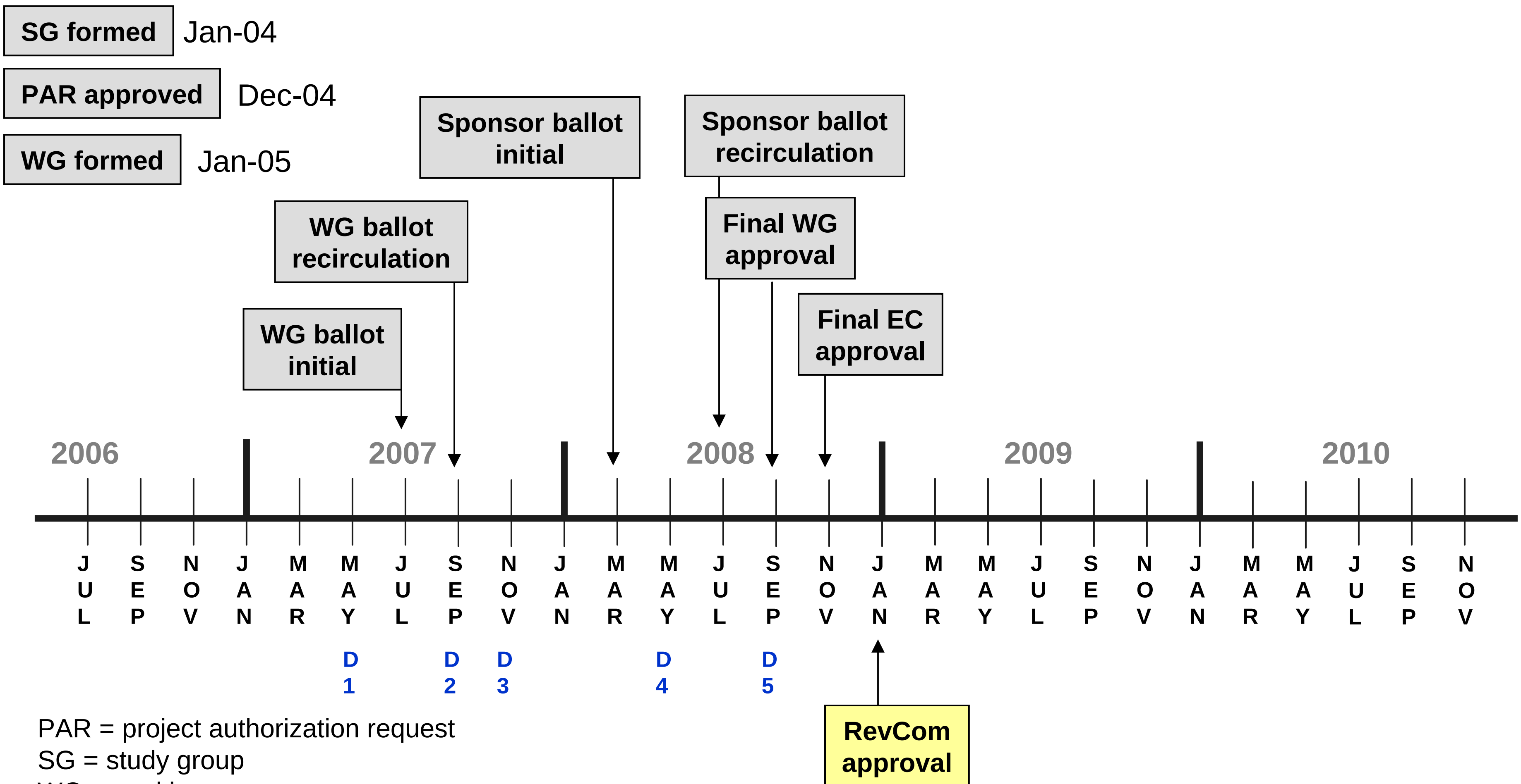
TGw timeline

802.11u Interworking With External Networks

- Main goal is to enable Interworking with external networks, including other 802 based networks such as 802.16 and 802.3 and 3GPP based IMS networks
- TGu specification deals with
  - Network discovery
  - Emergency call support (e911)
  - Roaming
  - Location and availability
- The network discovery capabilities give a station looking to connect information about
  - Networks in range
  - Service providers
  - Subscription status with service providers
  - Type of QoS that's available and whether the network is suitable for services like VoIP or video
- 802.11u makes 802.11 networks more like cellular networks where such information is provided by the infrastructure

802.11u Timeline



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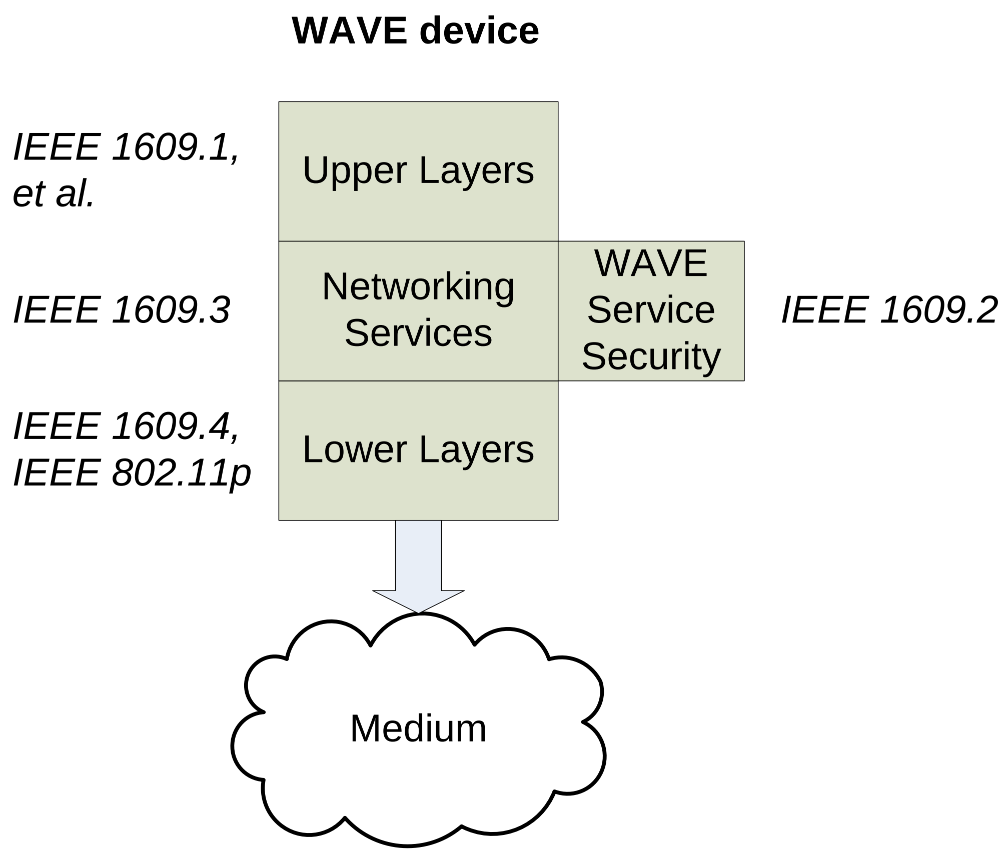
TGr timeline

802.11p Wireless Access Vehicular Environment (WAVE)

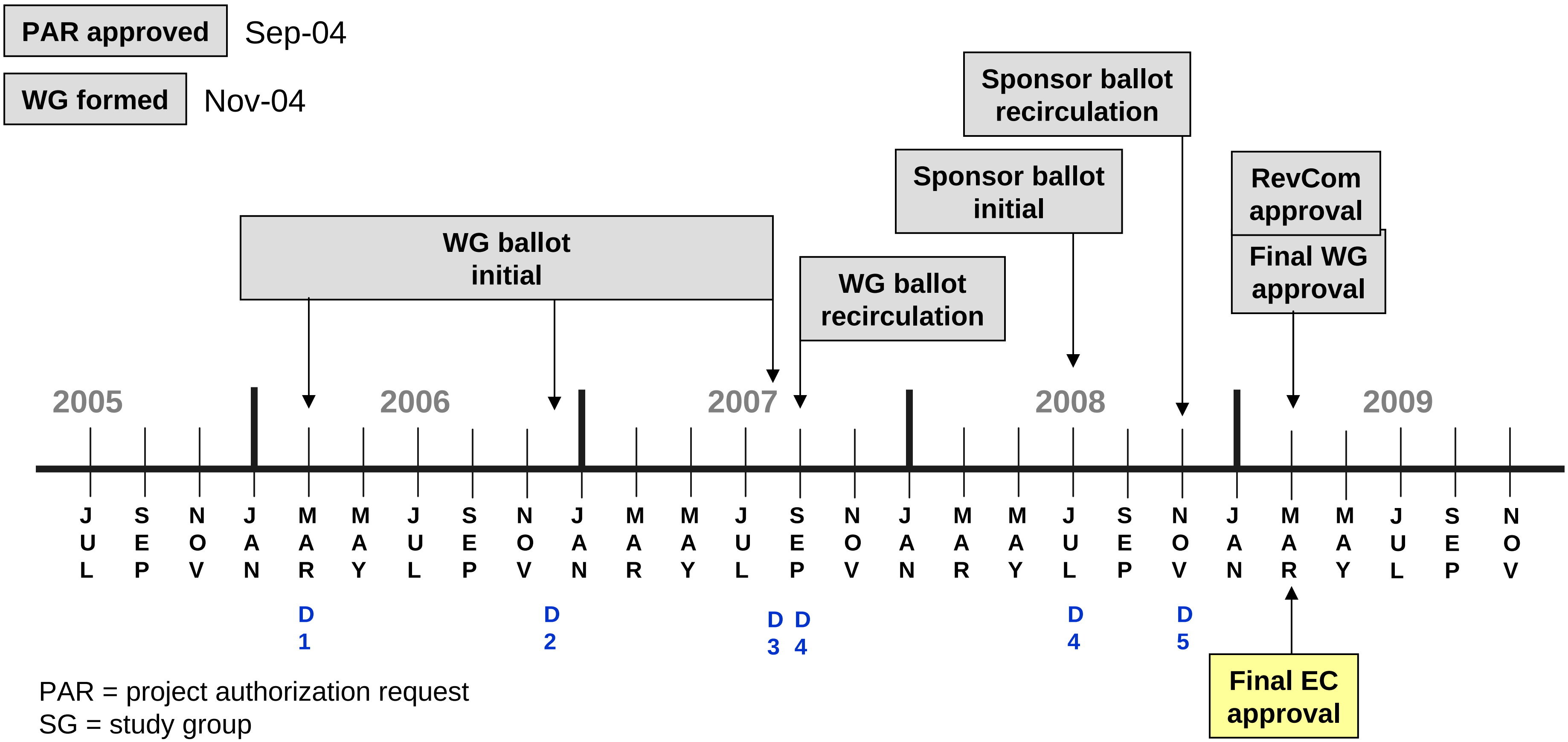
- Transportation communications systems under development by Department of Transportation (DoT)
- 802.11p is the PHY in the Intelligent Transportation Systems (ITS)
- WAVE is also known as DSRC (Dedicated Short Range Communications)
- WAVE/DSRC is the method for vehicle-to-vehicle and vehicle to road-side unit communications and is intended for…
  - Public safety
  - Collision avoidance
  - Traffic awareness and management
  - Traveler information
  - Toll booth payments

802.11p WAVE/DSRC

- Operates in the 5.9 GHz frequency band dedicated by the FCC for WAVE/DSRC
- This band falls right above the 802.11a band, making it supportable by the commercial 802.11a chipsets



802.11p Timeline



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TGp timeline

TGT – 802.11 Performance Testing

- Defines methods and metrics for evaluating performance of 802.11 devices and systems
- TGT will produce ‘recommended practices’ document, 802.11.2
- Primary metrics directly impact user experience
- Secondary metrics indirectly impact user experience
- Framework section describes how metrics should be used to predict application performance
  - Data applications such as file transfers, email, etc.
  - Streaming video applications
  - Voice applications

TGT Conducted and Over-the air Test Setups

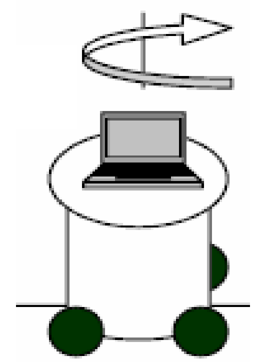
octoScope

Conducted

- Throughput vs. attenuation
- Transmit rate adaptation
- Antenna diversity
- Adjacent channel interference
- BSS transition time
- Fast BSS transition time
- Receiver sensitivity in a conducted environment
- Multicast forwarding rate
- Client association rate
- Client database capacity
- Power consumption

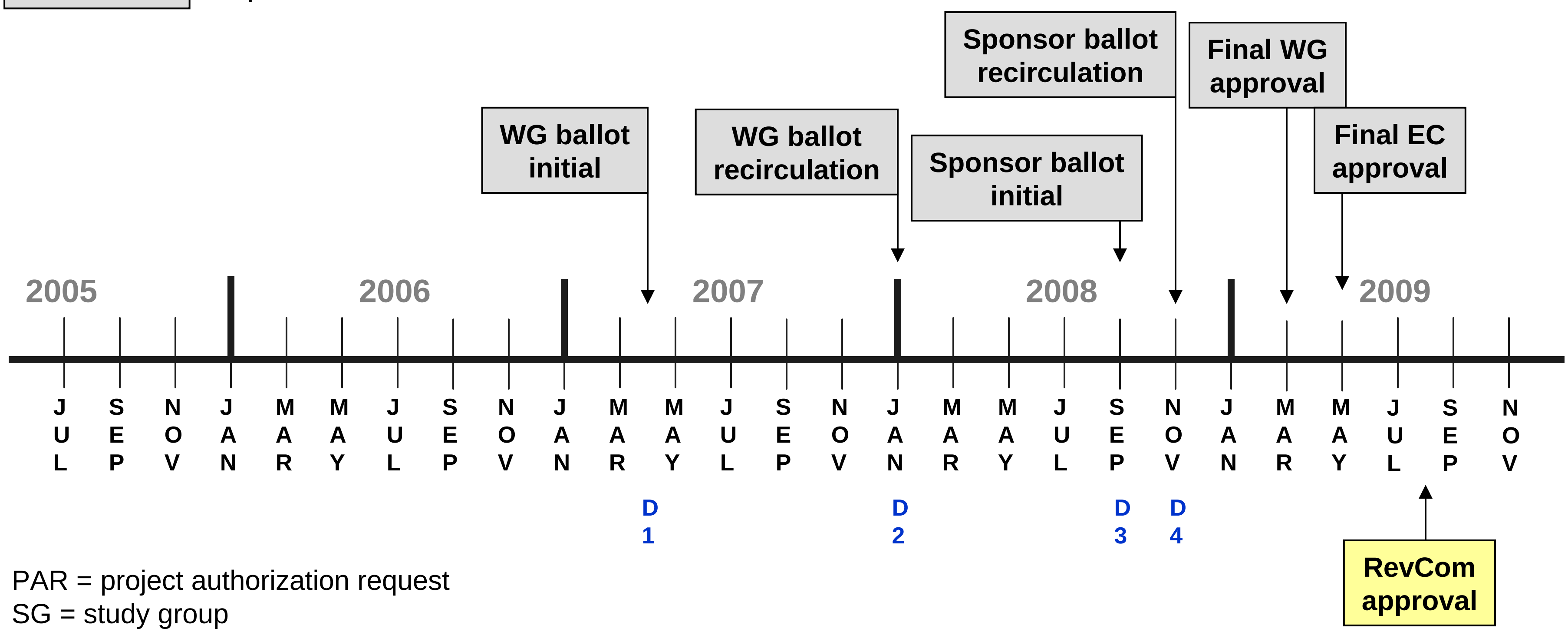
Over-the-air

- Throughput versus attenuation in an OTA environment
- Throughput versus range in an OTA environment



802.11T (802.11.2) Timeline

SG formed	Jan-04
PAR approved	Aug-04
WG formed	Sep-04



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TGT timeline

802.11 Study Groups

- **DLS SG** – Direct Link Setup
  - Direct station to station communications without the need to have the AP repeat all traffic
- **QSE SG** – QoS Extensions
  - Incompatibilities between the WMM (wireless multimedia) protocol defined by the Wi-Fi Alliance and 802.11e
- **VHT SG** – 1 Gbps Very High-Throughput
  - 1 Gbps nomadic wireless interface; initially started in response to ITU-T AMT-Advanced solicitation
- **VTS SG** – Video Throughput
  - Video transport protocol requirements

Agenda

- **9:00 – 10:15 am** **Overview of the IEEE 802 standards**
- **10:15 – 10:25 am** **Break**
- **10:25 – 11:40 am** **Innovations from the Task Groups**
- **11:40 – 11:50 am** **Break**
- **11:50 – 1:05 pm** **Real World Experience with WLANs**
  - **Dorothy Stanley, Senior Standards Architect, Aruba Networks**
  - **Geri Mitchell-Brown, Wi-Fi Strategist and Director of Technical Business Development, SpectraLink, now a part of Polycom**
- **1:05 – 2:05 pm** **Lunch**
- **2:05 – 3:20 pm** **Practical Experience with Prioritization and Mesh Networking Strategies**
  - **Mathilde Benveniste, Research Scientist, Avaya Labs**
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