IEEE Standardization

802.11s & 802.15.5 Wireless Mesh Networks
as an example

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2005-11-04, Mittweida

Overview

- IEEE standardization
  - 802 Working Group
- Wireless Mesh Networks
  - General problem statement
  - IEEE 802.11s, Mesh WLAN
  - IEEE 802.15.5, Mesh WPAN
- Industry Alliances
- Summary

The Institute of Electrical and Electronics Engineers (IEEE)

- >368 225 members
- >150 countries
- Merge in 1963
  - American Institute of Electrical Engineers (AIEE)
  - Institute of Radio Engineers (IRE)

- Leading authority
  - Aerospace
  - Computers
  - Telecommunication
  - Biomedical engineering
  - Electric power
  - Consumer electronics

802

IEEE 802 – LAN/MAN Standards Committee (LMSC)

- Local Area Network (LAN)
- Metropolitan Area Network (MAN)
- Mainly lowest 2 layers of OSI reference model
- Individual Working Group (WG) for each area
- Plenary sessions in March, July, and November

802.11

802.11 – Wireless LAN (WLAN) Working Group (WG)

- Chairman: Stuart Kerry (Philips)
- 491 Voting Members (2005-09)
- Most successful WLAN standard
- Wide scope of applications
- Largest group in 802

802.11 – Task Groups (TG)

- TGa
  - OFDM PHY at 5GHz, 54Mb/s, finished
- TGb
  - High-Rate DSSS at 2.4GHz, 11Mb/s, finished
- TGc
  - Bridge operation, finished
- TGd
  - Country specific elements, finished
- TGe
  - Support for QoS, finished
- TGf
  - Inter Access Point protocol, finished
- TGg
  - OFDM PHY at 2.4 GHz, 54Mb/s, finished
- TGh
  - Regulatory elements for 5GHz operation in Europe, finished
- TGi
  - Security enhancements, finished
- TGj
  - Regulatory elements for 5GHz operation in Japan, finished
- Publicity Committee (PC)
- TGk
  - Radio Resource Measurements
- TGm
  - Maintenance of the standard, interpretations
- TGn
  - High Throughput PHY & MAC, 100Mb/s on top of MAC
- TGp
  - Wireless Access for the Vehicular Environment (WAVE)
- TGr
  - Fast BSS transition group
- TGs
  - ESS Mesh
- TGt
  - Recommended Practice for Evaluation of 802.11 Wireless Performance
- TGu
  - Interworking with External Networks
- TGv
  - Wireless Network Management
- TGw
  - Protected Management Frames

802.11 – Standing Committees (SC) & Study Groups (SG)

- SC Publicity
- SC JTC1-SC6
  - ISO/IEC Joint Technical Committee 1 (Information Technology Standards)
    - Sub Committee 6 (Telecommunications and information exchange between systems)
- SC WNG
  - Wireless Next Generation
  - Incubator for new SGs
  - Chaired by TK Tan (Philips)
- SG APF-AH
  - Access Point Functionality
- SG CBP
  - Contention Based Protocols

802.11 – TGe

- Support for Quality of Service (QoS)
- Decentralized QoS access
  - Enhanced Distributed Channel Access (EDCA)
  - Probability driven
- Data block transmission
  - Efficiency increase
- Centralized QoS access
  - Hybrid Coordination function Channel Access (HCCA)
  - Strict QoS guarantee possible
- Finished 2005-09!

802.11 – TGk

- Radio resource measurement
  - Support for WLAN service providers
  - Channel busy time
  - Neighborhood reports

802.11 – TGm

- Maintenance
  - Comment resolution
  - Integration of interpretation
- Recombine amendments to united standard
  - 802.11 + a, b, d, g, h, j

802.11 – TGn

- High Throughput
  - ≥100Mb/s on top of MAC
  - Various usage cases
    - Simulation scenarios defined
    - Infrastructure based
    - No considerations of different WG needs
  - PHY definition
    - Mainly OFDM proposals
    - Various MIMO proposals
  - MAC definition
    - Enhancements to standard 802.11 MAC
  - Competing industry consortiums
    - TGnSync
    - WWISE
    - MITMOT
  - Enforced merger
    - Enhanced Wireless Consortium
- Mass market

802.11 – TGp

- Wireless Access in Vehicular Environment
- Coordinated with ISO TC204/WG16
- ASTM E2213-02 standard based on IEEE 802.11a
- US government agencies plan installing roadside infrastructure
  - Widespread deployment of roadside APs
  - Standard car equipment
  - Aftermarket installation
- Applicable on a global basis
  - Transactions in ms
  - At least 200 km/h
  - Car2Car communication
  - Collision avoidance
  - Traveler information
  - Vehicle to Internet
  - Roadside to vehicles
  - Commercial vehicle operations
    - Toll collection
    - Rail and transit agencies
    - Transit operations
    - Traffic management
- → Car2X communication

802.11 – TGr

- Fast Basic Service Set (BSS) transition
  - Multiple concurrent associations
  - Pre shared keys
  - Quick scan mechanisms
  - Support for VoIP when roaming

802.11 – TGs

- Extended Service Set (ESS) Mesh
- Access Point based
- Transparent Mesh to legacy stations
- Easy deployment
- Wide scope of applications
- Limited scope of Mesh size (≤32 APs)
  - No MANET concept
  - Focus on market success

802.11 – TGt

- Wireless Performance Prediction
- Definition of test scenarios
- List of variables that impact performance
  - Mechanisms to predict performance
- Guidelines to optimize performance
  - Design of wireless networking components
  - Installation of wireless networks
- Comparison criteria
  - Different vendors

802.11 – TGu

- Wireless Interworking with External Networks
- Hotspot use
  - ISPs
  - Cellular operators
  - Network selection
  - Accounting
  - Operator advertisement
- Resource management
  - End-to-end resource allocation
  - Admission control
  - Resource monitoring
- Access Router – layer 3 mobility
  - MAC address anonymity
  - Channel Management
  - User registration
  - User clear down
  - Network-Network Interface
  - Policy enforcement
  - Access control
  - External QoS mapping
  - User access revocation

802.11 – TGv

- Wireless Network Management
- In-Band management
  - "Wireless Reset" for APs
  - Wireless SNMP
  - Monitoring
- Service Provider/Network Operator needs to consider

802.11 – TGw

- Protected management frames
  - Deauthentication, disassociation etc.
- Integrity
- Origin authenticity
- Replay protection

802.11 – SC WNG

- Wireless Next Generation
- Chairman: TK Tan (Philips)
- Pool for new
  - Ideas
  - Study Groups (SG)
  - Various presentations
- Wide scope

SG APF-AH

- Access Point Functionality
  - Driven by IETF demands
  - Definition of “What is an AP?”
  - Mandatory & optional features
  - Interface definition for higher layers

SG CBP

- Contention Based Protocols
- US, FCC project
  - 3650-3700 MHz Broadband Wireless Services allocation (FCC 05-56)
- Wide area networks
- No regulation on access scheme
  - Limited areas
    - Border to Canada & Mexico
    - Satellite control centers

Wireless Mesh Networks

Evolution of Wireless networks

Mobile Phone (GSM, CDMA)
Cordless Phone (DECT etc.)
IEEE 802.11
IEEE 802.11g
IEEE 802.11a
IEEE 802.11n
Wireless USB (WiMedia)

- Constant performance increase
  - Sensitive coding & modulation
    - High wireless signal quality needed
- Range decreases

The need for Wireless Mesh Networks

- Limited range
  - 1Gb/s WLAN & WPAN
  - Cellular (UMTS, HSDPA)
- Limited transmission power
  - Regulatory bodies
  - Exposure to human beings
- Limited bandwidth
  - Unlicensed bands
  - Reuse of scarce resource necessary

Coverage?

→ Multiple Access Points

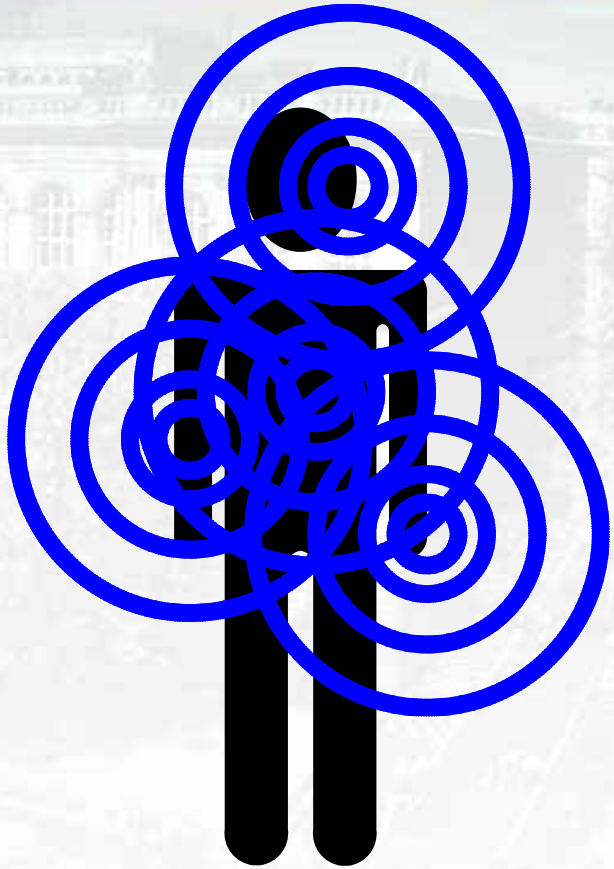
- Deployment costs
  - Power almost everywhere
  - Backbone access expensive
- No wired IT infrastructure in CE market
- Backhaul to base station expensive

→ Extend coverage via wireless multi-hop

→ Wireless Mesh networks

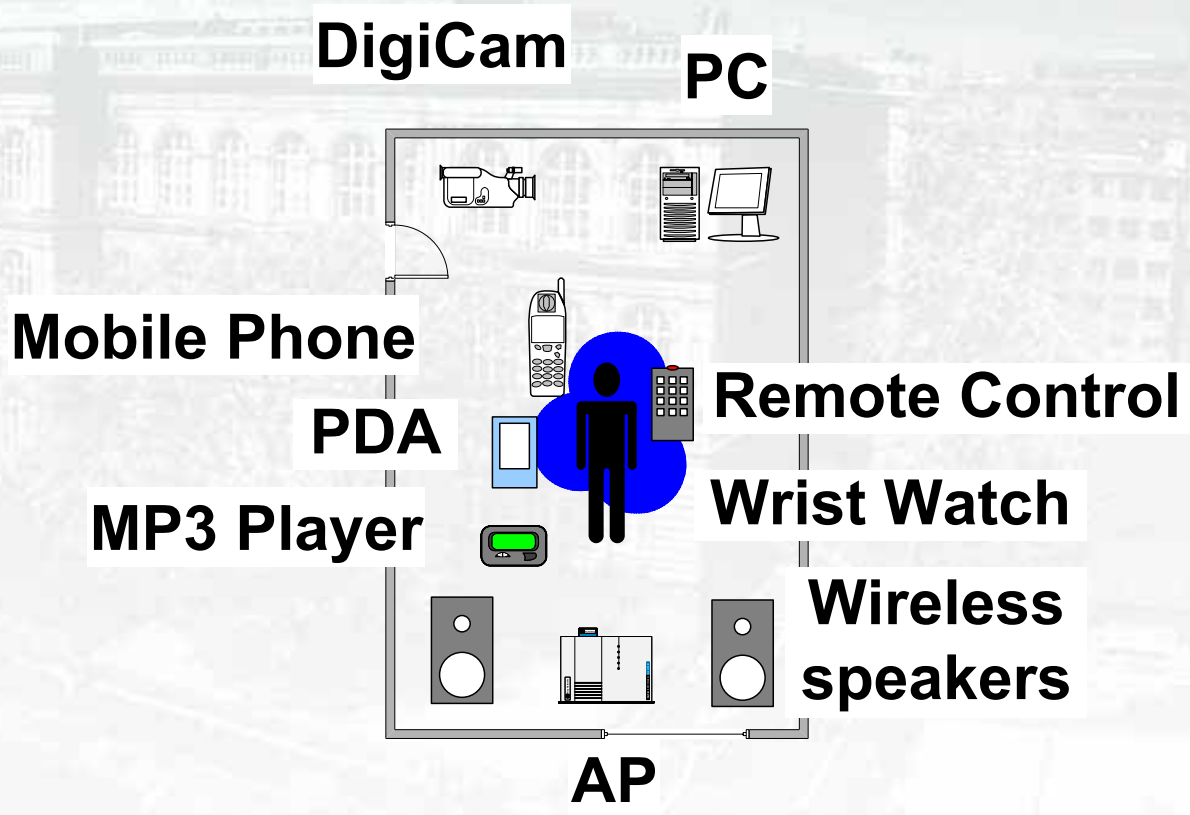
Ubiquitous Mesh Networks

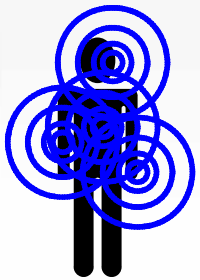
- WPAN, 802.15.5
  - Body



Ubiquitous Mesh Networks

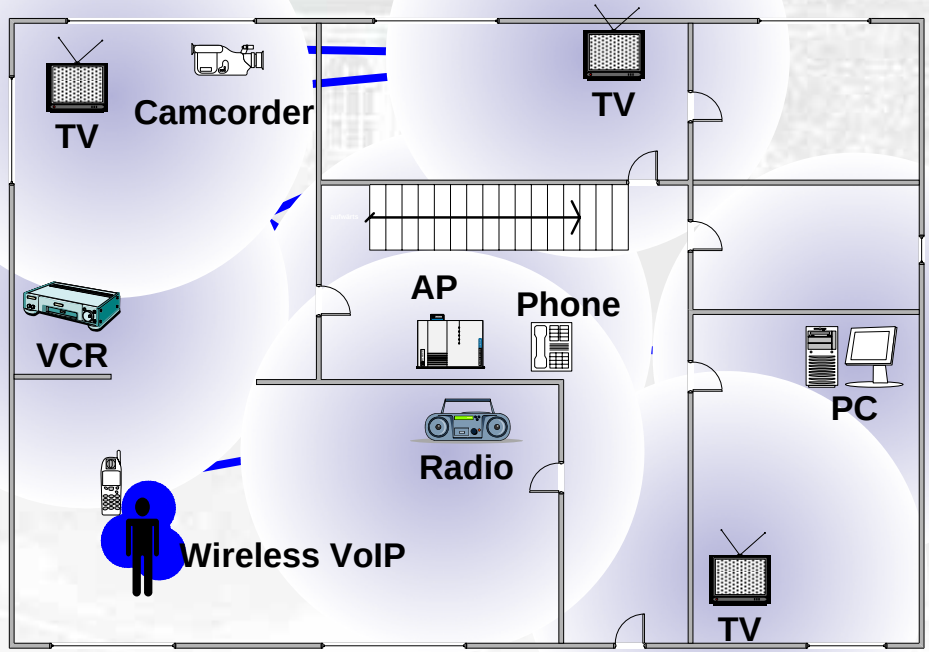
- WPAN, 802.15.5
  - Body
  - Single room

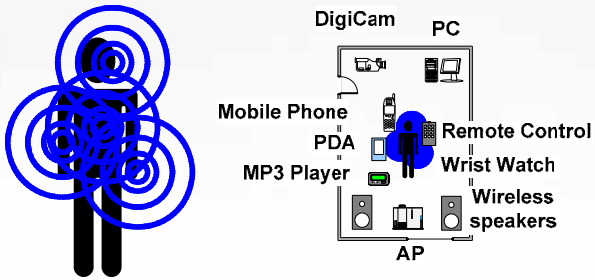




Ubiquitous Mesh Networks

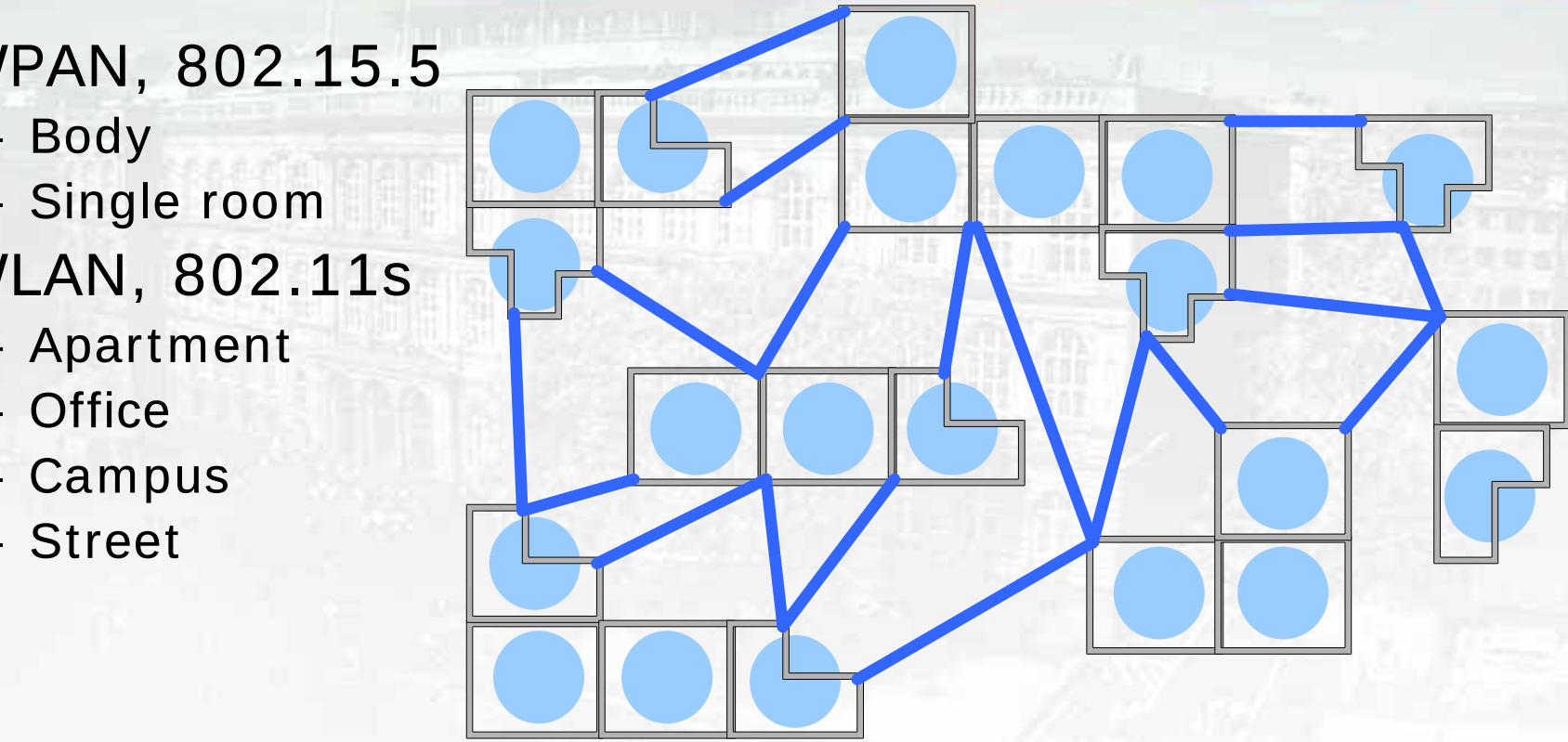
- WPAN, 802.15.5
  - Body
  - Single room
- WLAN, 802.11s
  - Apartment
  - Office

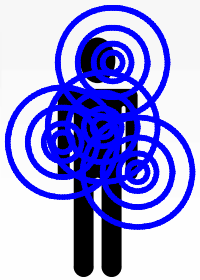


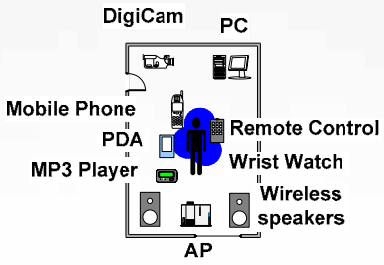


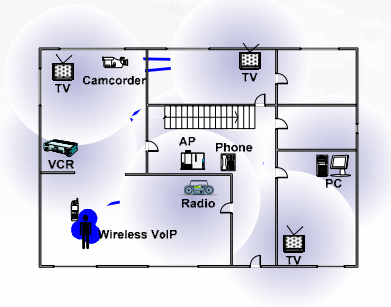
Ubiquitous Mesh Networks

- WPAN, 802.15.5
  - Body
  - Single room
- WLAN, 802.11s
  - Apartment
  - Office
  - Campus
  - Street



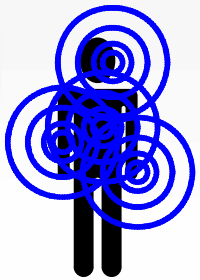


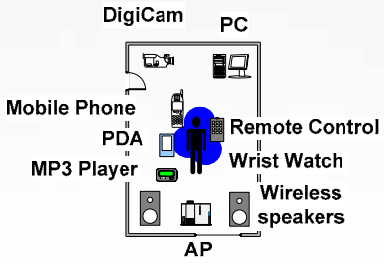


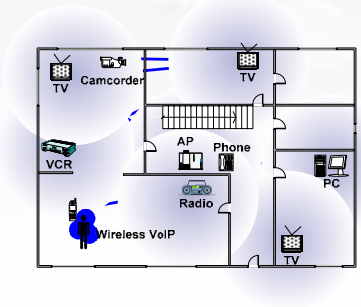


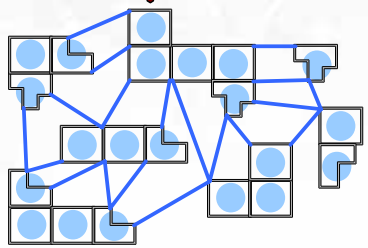
Ubiquitous Mesh Networks

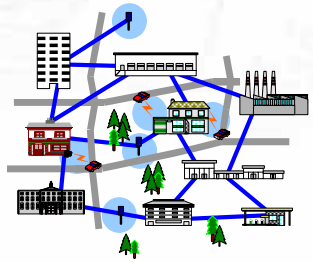
- WPAN, 802.15.5
  - Body
  - Single room
- WLAN, 802.11s
  - Apartment
  - Office
  - Campus
  - Street
- WMAN, 802.16
  - City

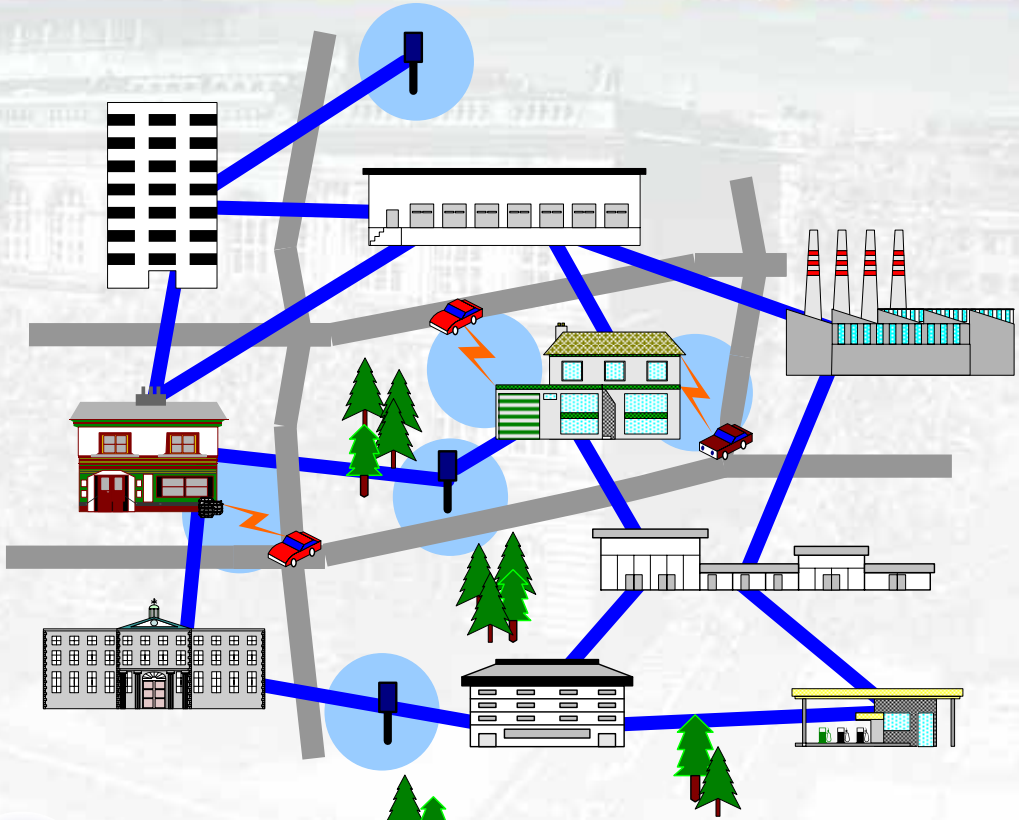






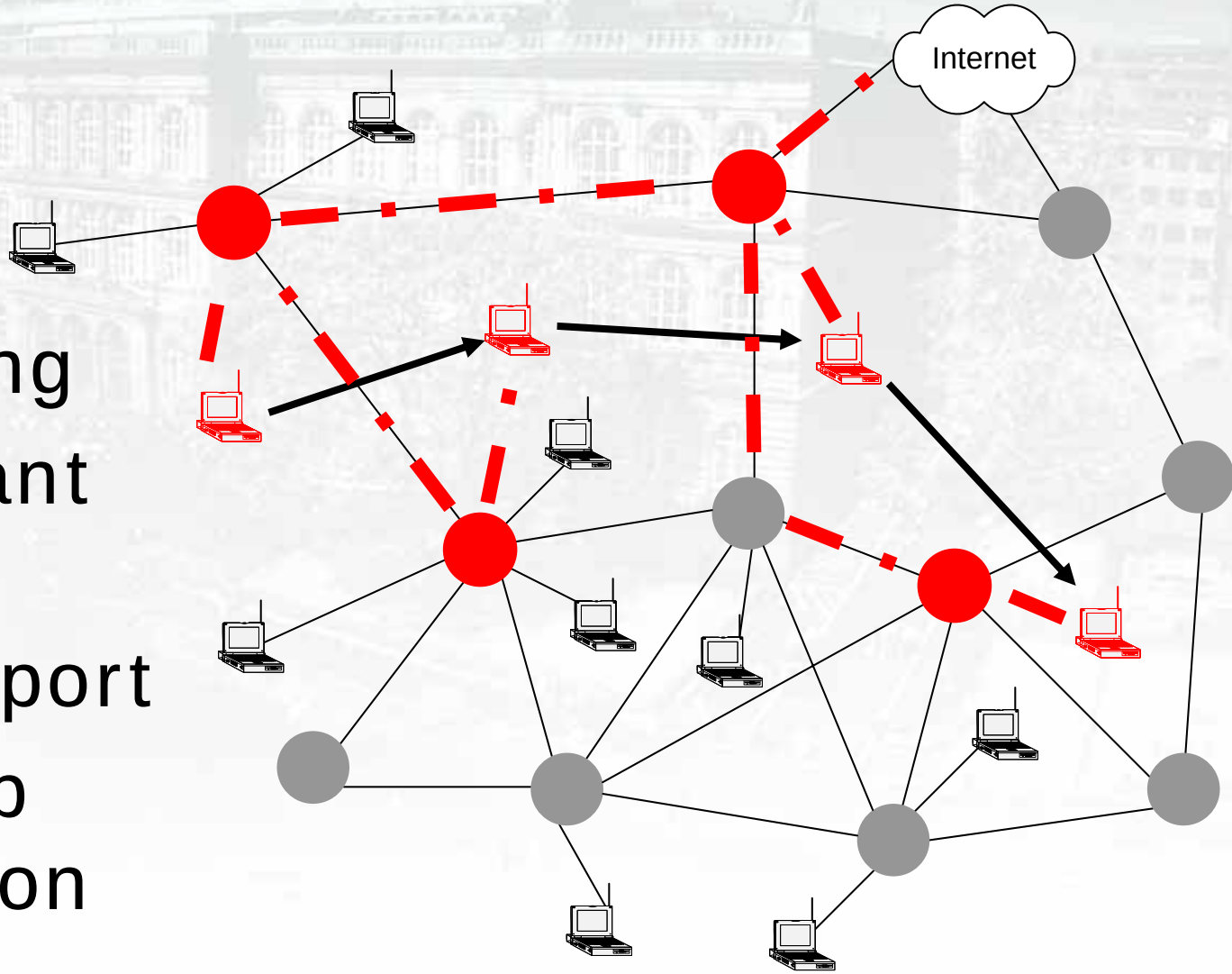






Challenges in Mesh networks

- Ad hoc
- Mobility
- Self organizing
- Redundant links
- QoS support
- Multi hop connection

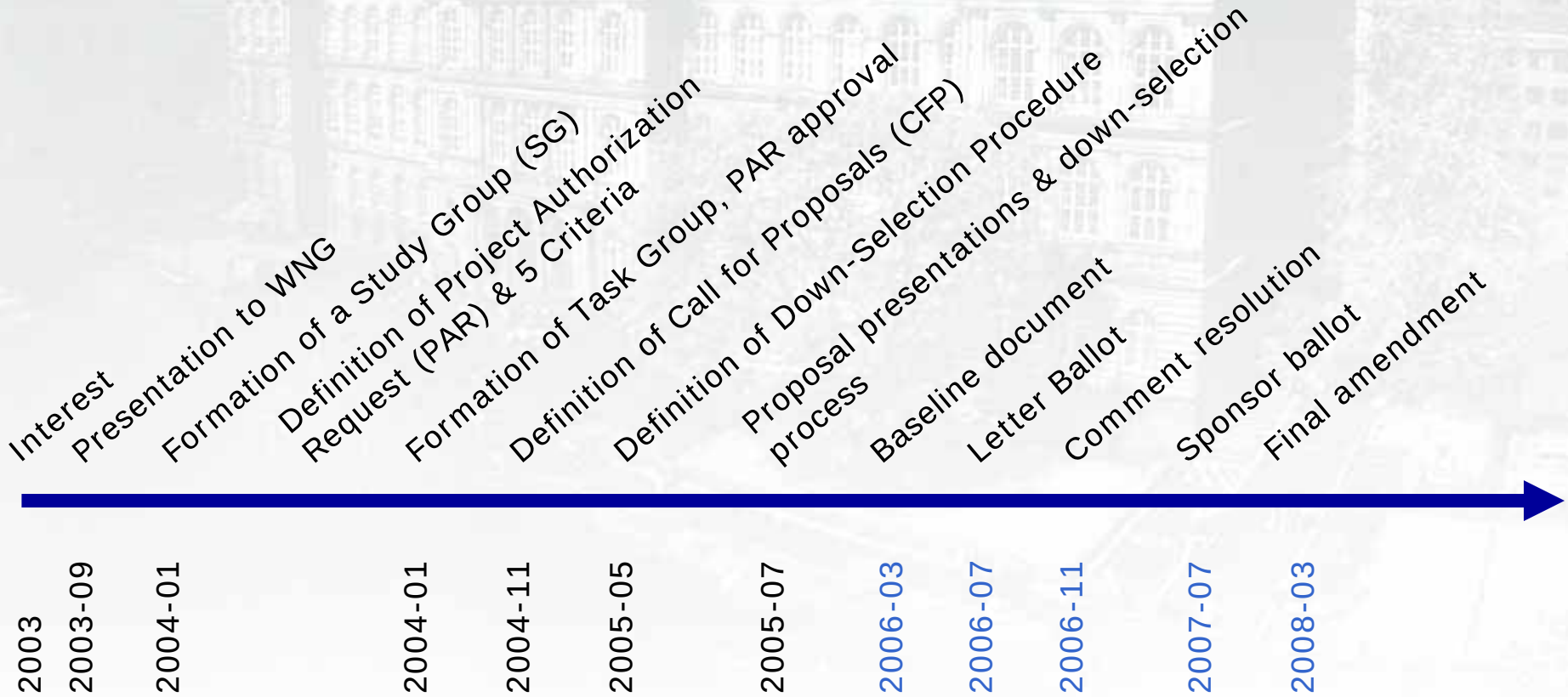


IEEE 802.11s Mesh WLAN

IEEE Standardization – Mesh in 802.11

- Active participation since 2003
- 802.11 voting member
- IEEE 802.11s
  - Mesh WLAN
  - ComNets cooperates with Wi-Mesh Alliance

IEEE 802.11 process – TGs as example



Usage scenarios for Mesh WLAN – IEEE 802.11s

Military Usage

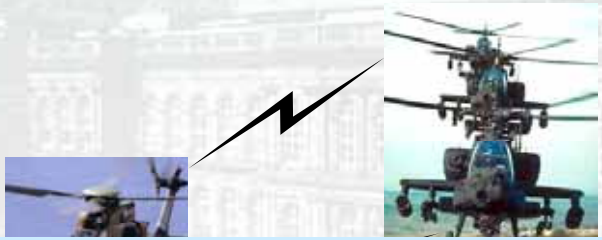
Battle field communication

Usage scenarios for Mesh WLAN – IEEE 802.11s

Military Usage

Battle fiel nication

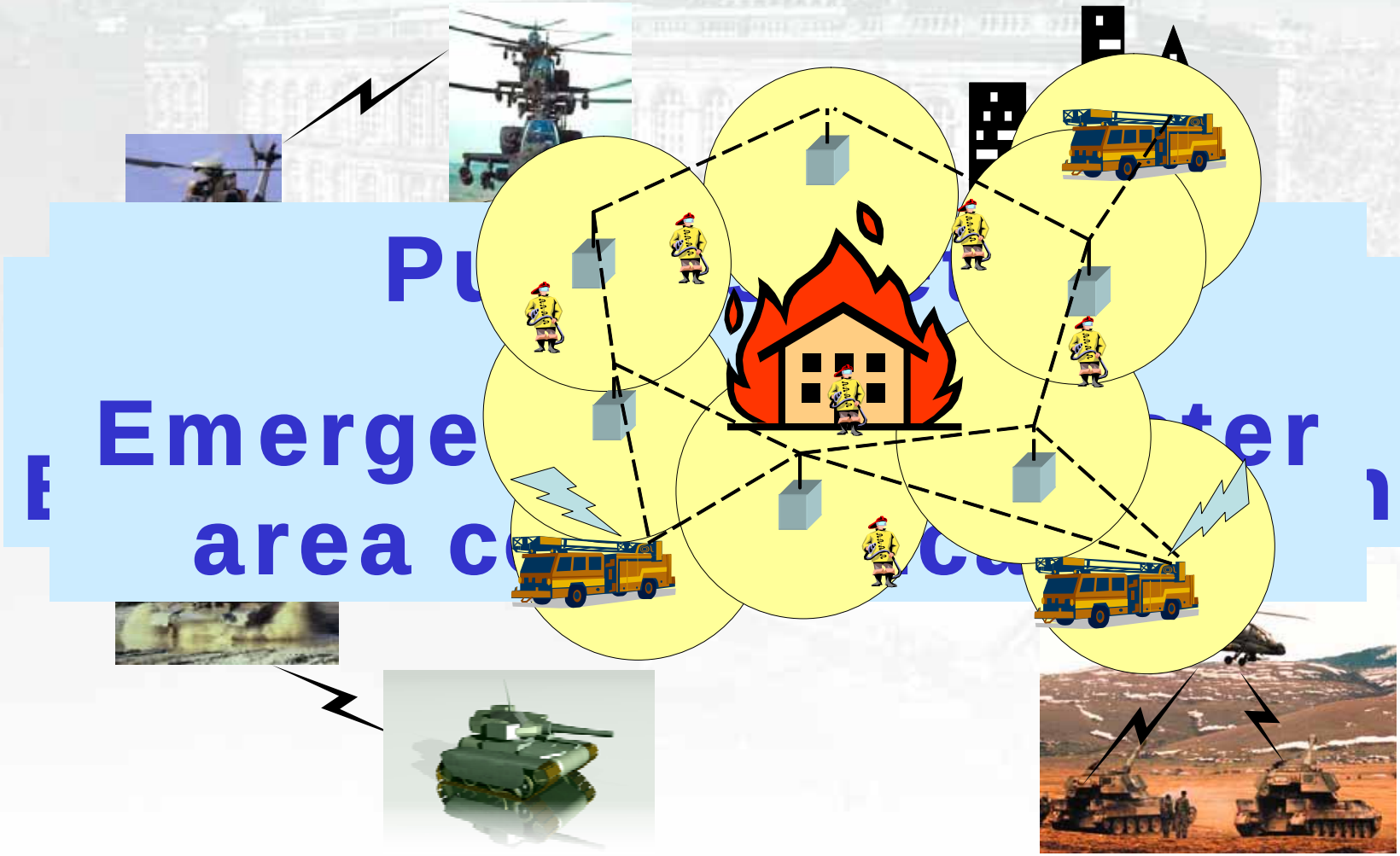
Usage scenarios for Mesh WLAN – IEEE 802.11s



Public safety

Emergency and disaster area communication

Usage scenarios for Mesh WLAN – IEEE 802.11s

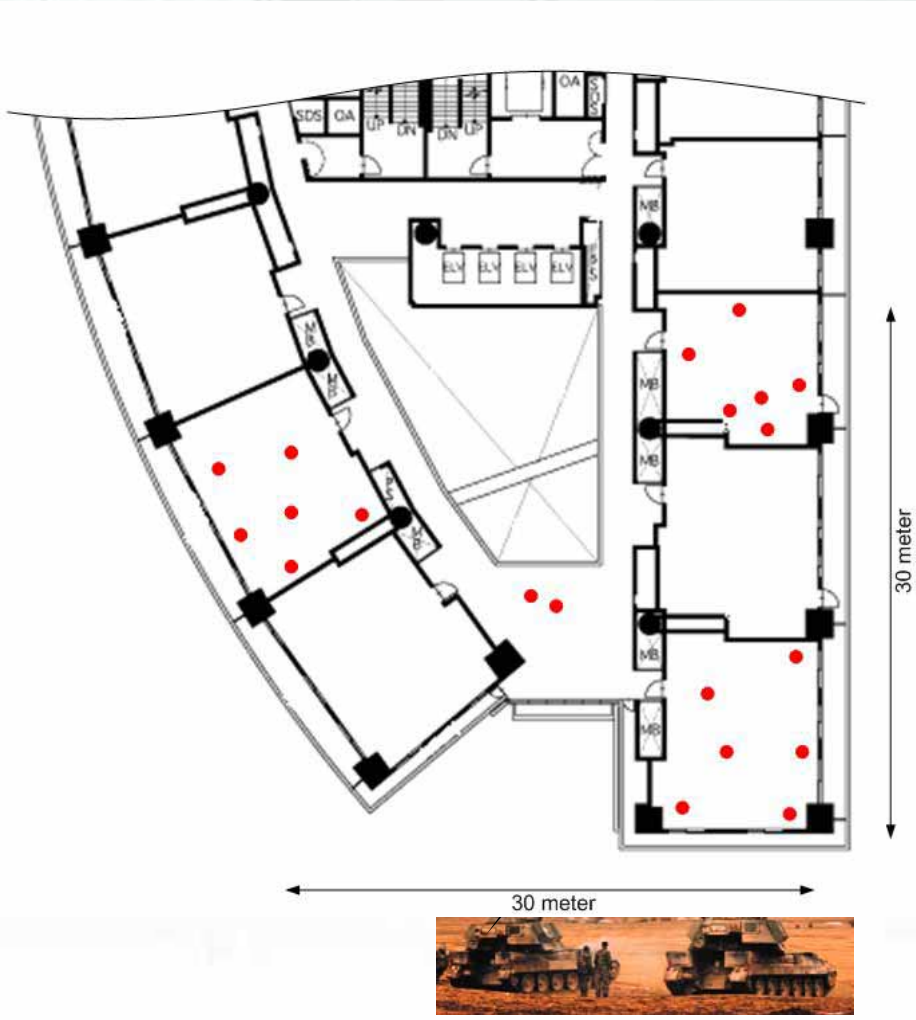


Usage scenarios for Mesh WLAN – IEEE 802.11s

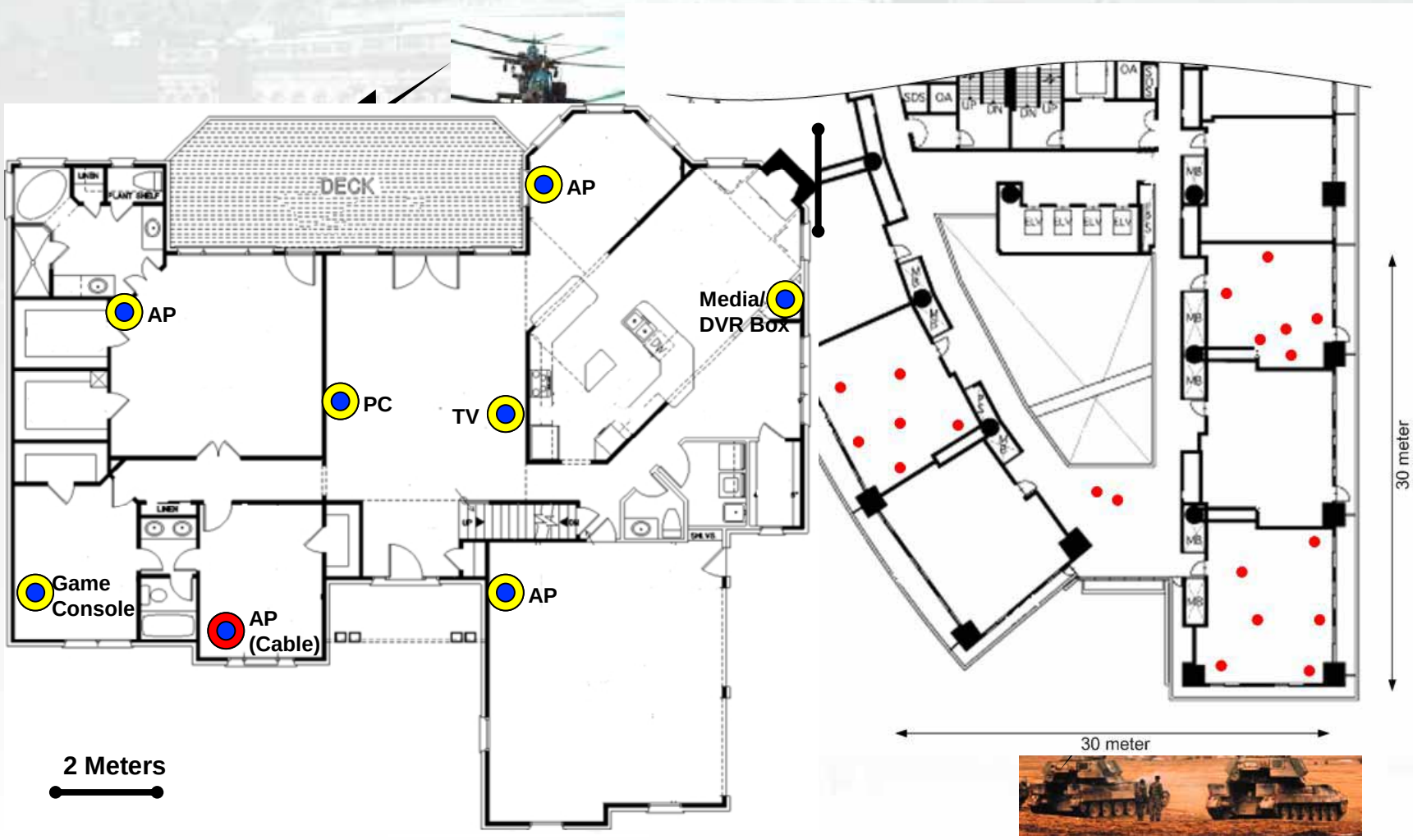
Residential

Consumer Electronics

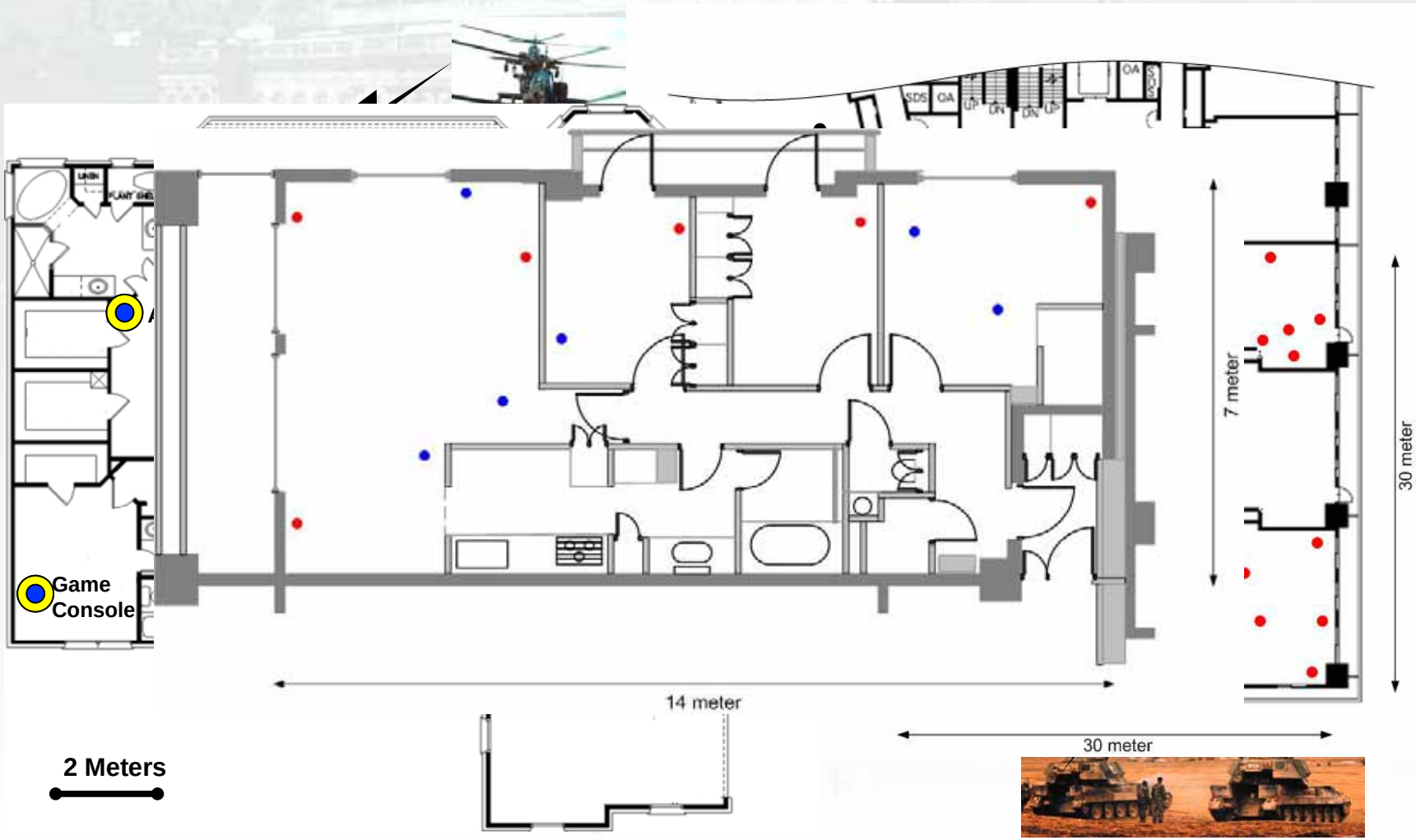
Usage scenarios for Mesh WLAN – IEEE 802.11s



Usage scenarios for Mesh WLAN – IEEE 802.11s



Usage scenarios for Mesh WLAN – IEEE 802.11s



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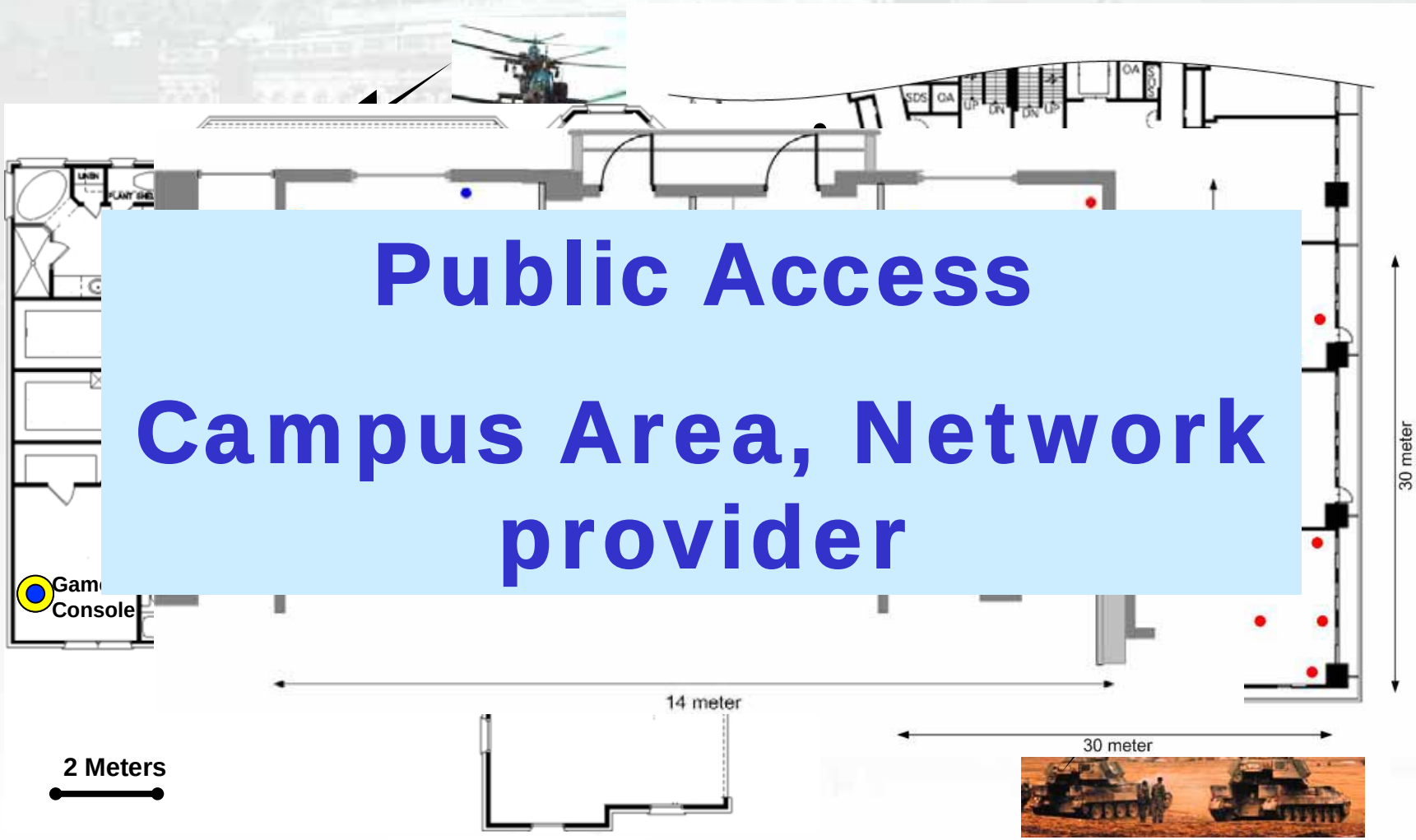

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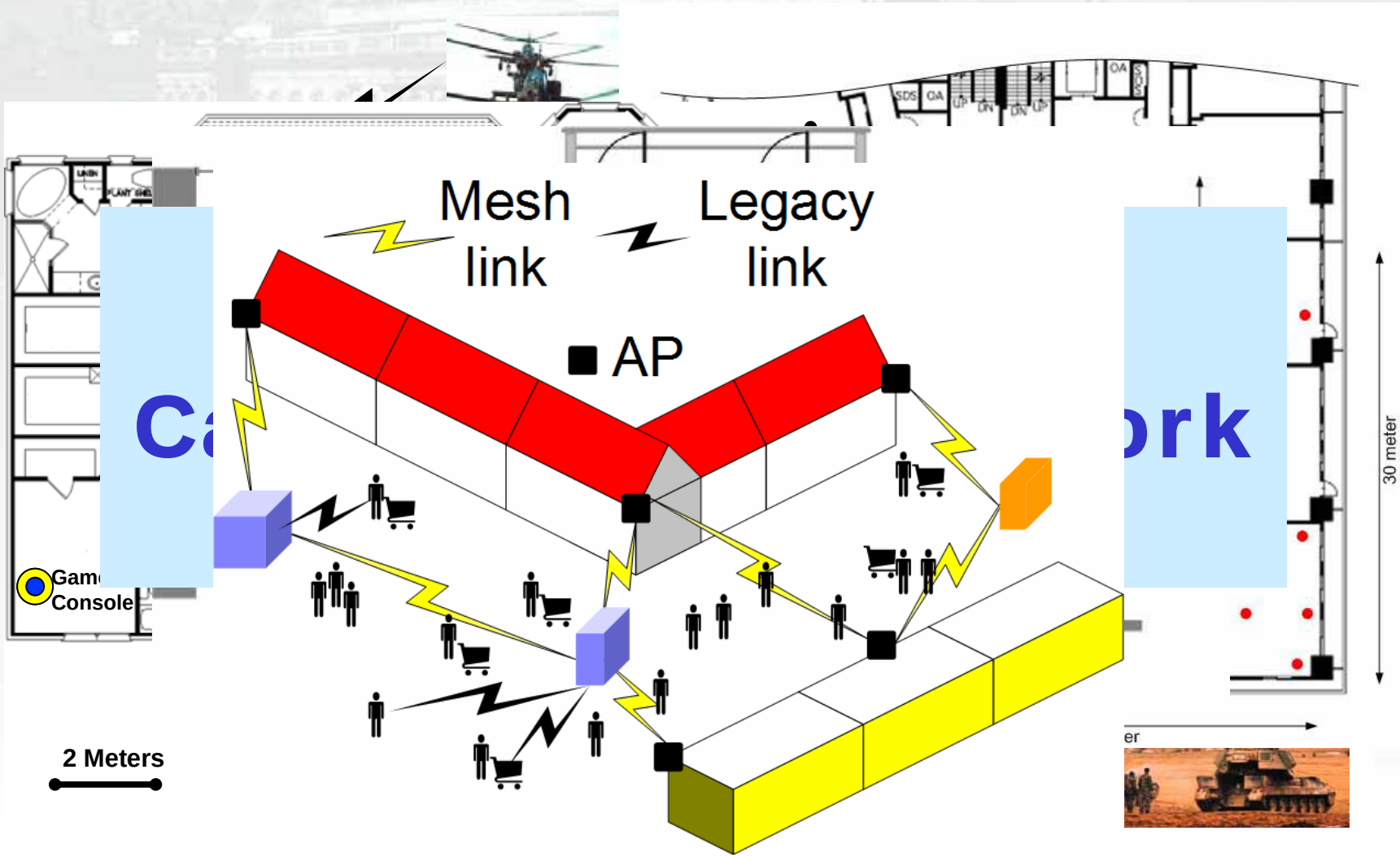
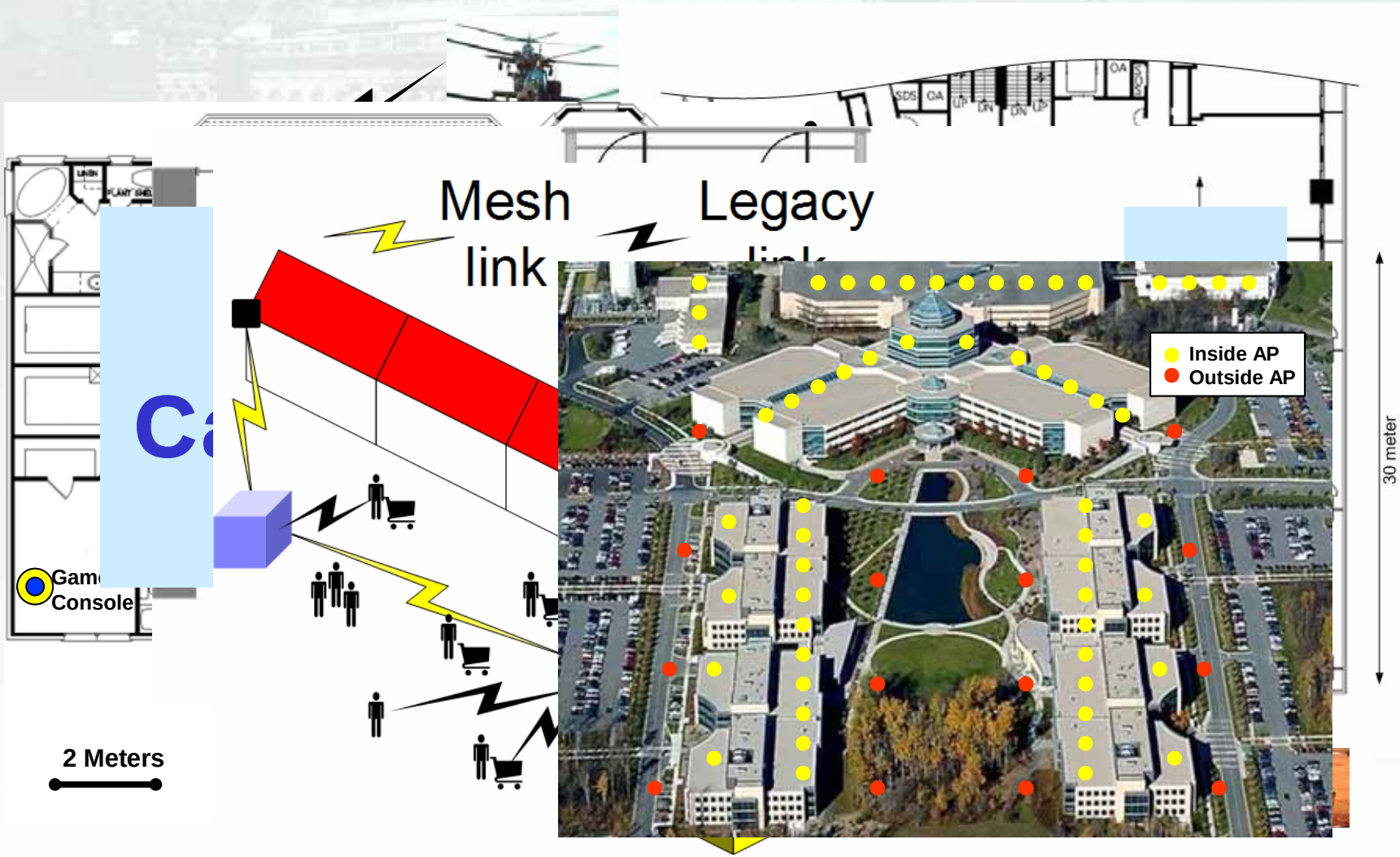
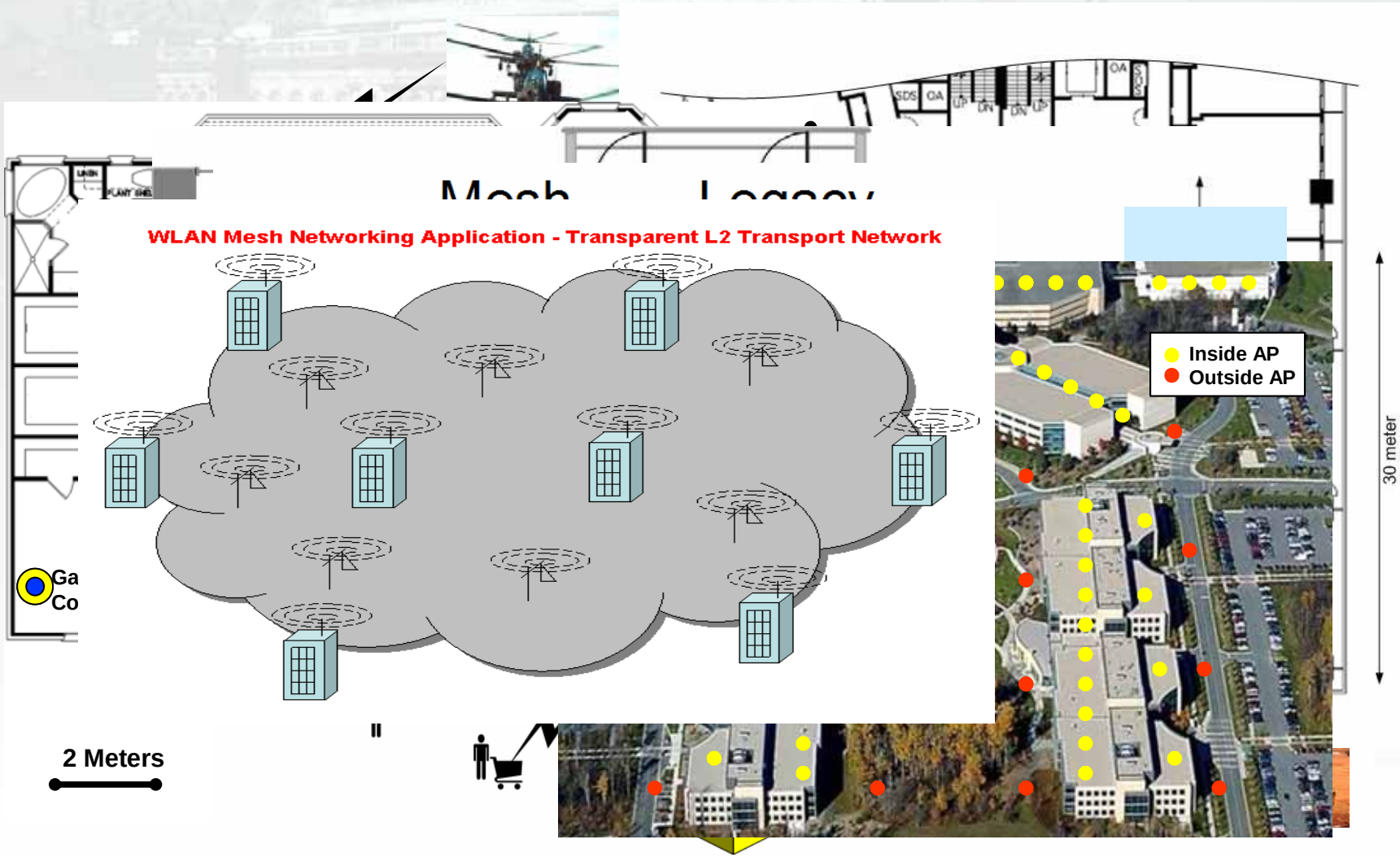


Usage scenarios for Mesh WLAN – IEEE 802.11s



Usage scenarios for Mesh WLAN – IEEE 802.11s



Usage scenarios for Mesh WLAN – IEEE 802.11s

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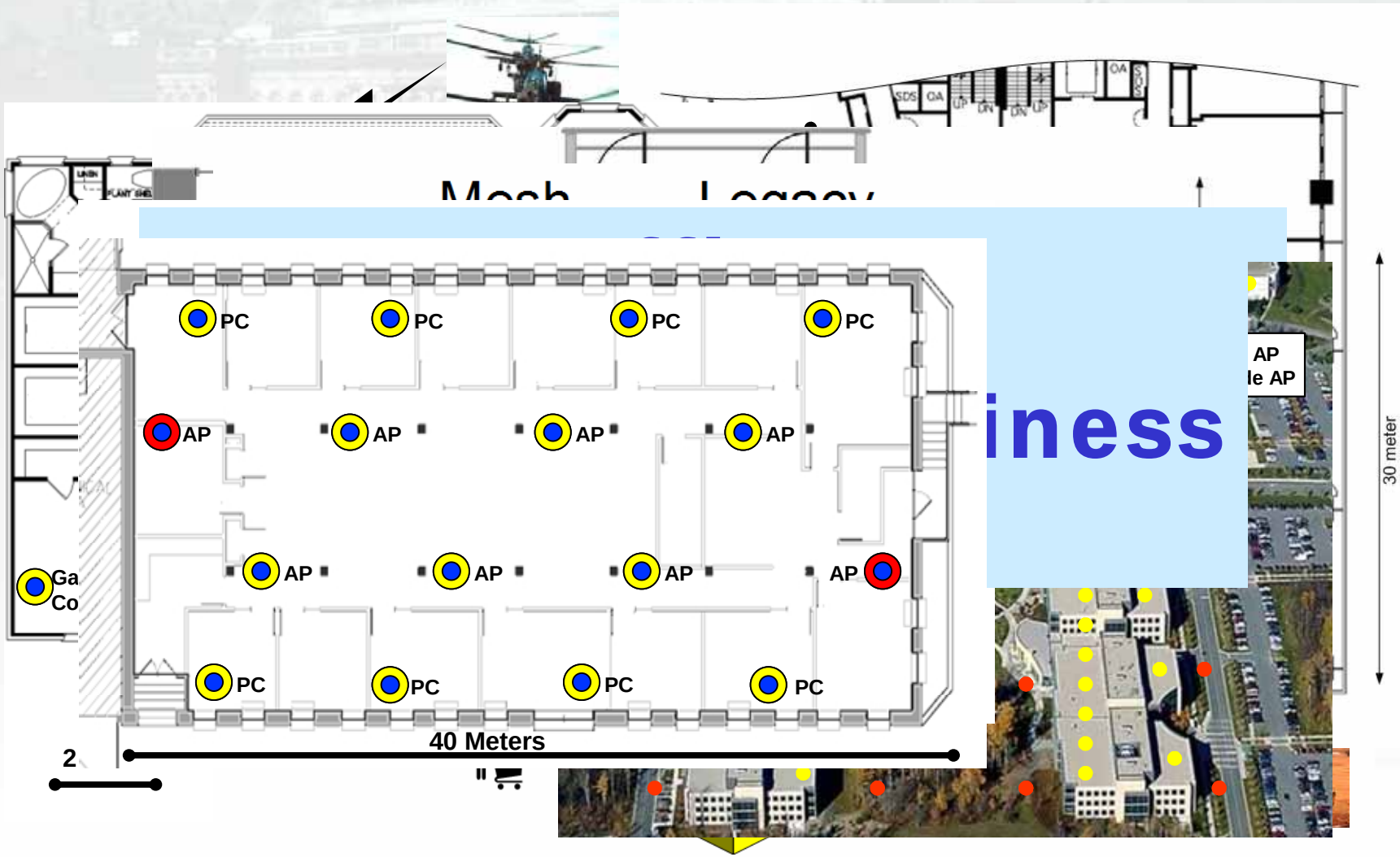
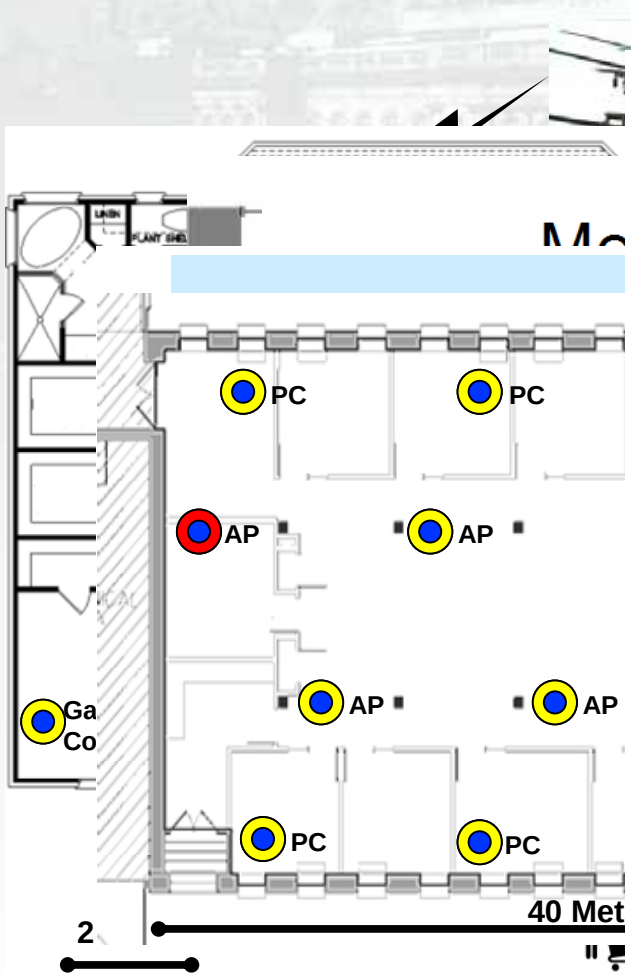
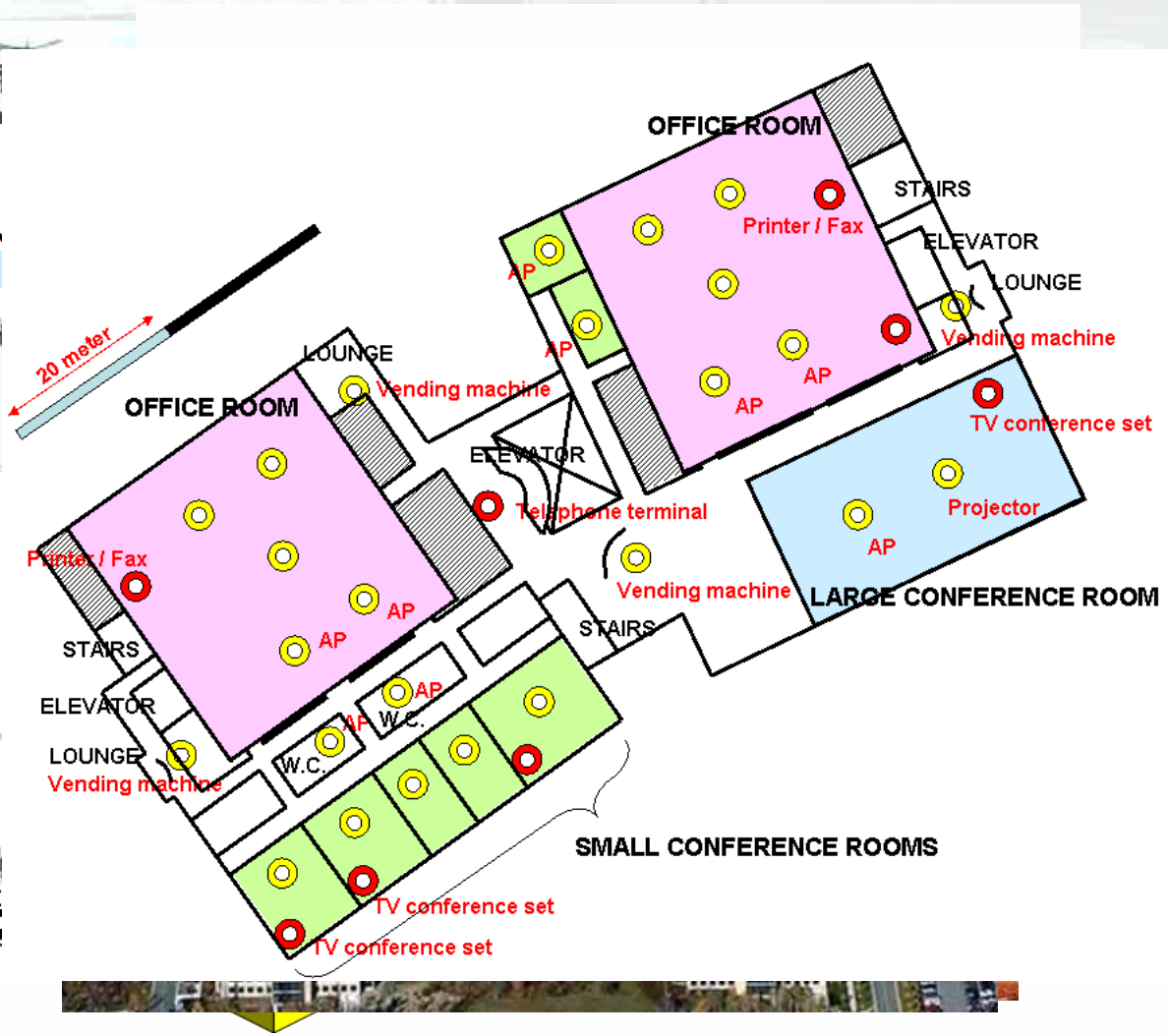


Usage scenarios for Mesh WLAN – IEEE 802.11s





IEEE 802.11s – Project Authorization Request

1. The proposed amendment shall be **an extension to the IEEE 802.11 MAC**.
2. The amendment will define an architecture and protocol for providing an IEEE 802.11 ESS Mesh [...] to create an **IEEE 802.11 Wireless Distribution System**
3. [...] over self-configuring **multi-hop** topologies.
4. An ESS **Mesh is functionally equivalent to a wired ESS**, with respect to the STAs relationship with the BSS and ESS.
5. A **target configuration is up to 32 devices** participating as AP forwarders in the ESS Mesh.
6. The **amendment shall utilize IEEE 802.11i** security mechanisms, or an extension thereof
7. [...] in which all of the APs are **controlled by a single logical administrative entity** for security.
8. The amendment shall allow the use of **one or more IEEE 802.11 radios** on each AP in the ESS Mesh.

Current 802.11s proposals

Rank	Proposal
1	SEE Mesh (Intel, Samsung, TI, Sony, NTT …)
2	Wi-Mesh Alliance (Philips, Nortel, Thomson, ComNets …)
3	Mesh Networks Alliance (Philips & ComNets)
4	Proactive Mesh (Oki et al.)

- July 2005 meeting
  - Low hurdle vote
- 15 proposals submitted
  - 3 eliminated
- September 2005 meeting
  - 6 mergers
  - 2 eliminated
- November 2005
  - 4 full proposals

Wi-Mesh Alliance

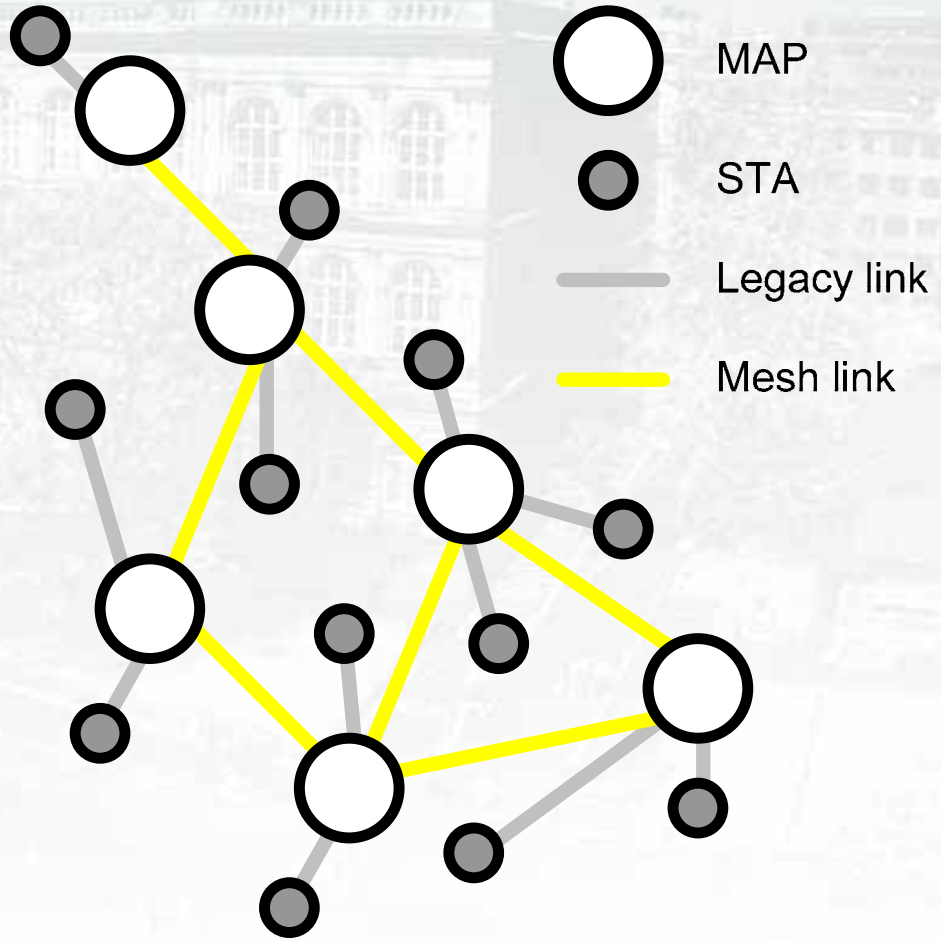
- IEEE 802.11s – Mesh WLAN
- Wi-Mesh Alliance member
  - Active participation since June 2005
  - Joint proposal
  - MAC additions
  - Highly spectral efficient

http://wi-mesh.org

Wi-Mesh Alliance members

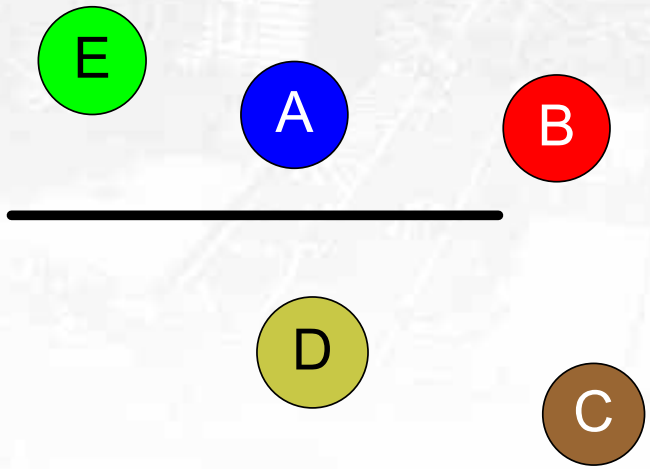
Legacy impacts Mesh WLAN

- Seamless integration
  - Legacy 802.11 stations (STAs) *AND*
  - 802.11s Mesh Access Points (MAPs)
- Fully backwards compatible
  - No changes to existing STAs needed
  - Mitigate interference from legacy to Mesh
- Support for 1 or more MAP radios



Mesh WLAN – Interference in dense networks

- Mutual interference (Stations, Mesh Access Points etc.)
  - Hidden & Exposed Nodes
  - Interference range exceeds reception range
    - RTS/CTS designed for single hop
    - Virtual carrier sense (Network Allocation Vector) often cannot be received
- 802.11 limits spatial frequency reuse (capacity)



MAC layer based packet forwarding ("routing")

- 802.11 Wireless Distribution System
  - Mesh WLAN must be transparent for
    - Stations
    - Higher layers
- IP layer blind for channel condition

→**Routing at MAC Layer**

- Extend IETF MANET concepts
  - On-demand, proactive or hybrid routing
- Additional input for routing decision
  - PHY mode, Packet Error, Transmit power, hop count, link load etc.

Mesh WLAN – A multi level approach

- MAC changes
  - Overcome multi hop limitations
- Channel measurements
  - 802.11 Task Group “k” concepts
- Multihop security
  - Extend 802.11i amendment
- Support Roaming (Task Group “r”)
- Routing concepts
  - Interface/Information for routing
  - Small scale Mesh WLAN
- Congestion & Call admission control
- Mesh WLAN segregation

IEEE 802.15.5
Mesh WPAN

IEEE Standardization – 802.15

- Wireless Personal Area Networks
- Active participation since 2003
- IEEE 802.15.3a (UWB PHY)
  - WiMedia Alliance proposal
  - Contribution to WiMedia MAC design
  - Distributed Reservation Protocol
- Mesh WPAN: 802.15.5

Industry Cooperations: WiMedia Alliance

- Active Member
  - Developed Distributed Reservation Protocol for MAC
  - Active participation in July & November 2005
  - Mesh enhancements for MAC
  - UWB communication
- Multiband OFDM PHY
- Wireless USB 2.0
- Competing MAC design to 802.15.3

http://wimedia.org

WiMedia Alliance members

Alereon, Inc.
Hewlett-Packard Company
Intel Corporation
Kodak
Microsoft Corporation
Nokia Corporation
Philips
Samsung Electronics Co., Ltd.
Sony Corporation
Staccato Communications
STMicroelectronics
Texas Instruments, Inc.
Wisair Ltd.
Analog Devices
Artimi Inc.
Broadcom Corporation
Cambridge Silicon Radio, Plc
Canon Inc.
Centro de Tecnologia de las Comunicaciones S.A. (CETECOM)
ESRD of CSIST
Faraday Technology Corporation
FOCUS Enhancements, Inc.
Hitachi, Ltd. Ubiquitous Platform Systems R&D Laboratory
Hong Kong Applied Science and Technology Research Institute Company Limited
Infineon Technologies NA
ITI Techmedia Limited
LeCroy Corporation
LG Electronics, Inc.
MCCI
Murata Manufacturing Co., Ltd.
NEC Electronics Corporation
Oki Electric Industry Co., Ltd.
Olympus Communication Technology of America
Stonestreet One
Synopsys Inc.
TDK Corporation
Telecommunications Technology Association (TTA)
Toshiba Corporation
Transdimension
TZero Technologies
Wionics Research - Realtek Group
WiQuest Communications
Adimos
Advantest Corporation
Blue7 Communications
Ellisys sarl
General Atomics
Institute of Computer and Communication Engineering, National Cheng Kung University
MindTree Consulting PVT. LTD
Mitsubishi Electric Corporation
NVIDIA Corporation
OrangeWare Corporation
Tektronix, Inc.
TRDA, Inc
WiMorph Communications Inc.
Wipro Limited
Allion Computer Inc.
Alpha Networks, Inc.
Asahi Glass Company Co., Ltd.
Catalyst Enterprises, Inc.
Cellink Co. Ltd.
Creative Labs, Inc.
ETRI Electronics and Telecommunications Research Institute
Fuji Electric Device Technology Co., Ltd.
Hong Kong University of Science and Technology, Department of EEE
Industrial Technology Research Institute
Institute for Information Industry
Konica Minolta Technology, U.S.A.
LucidPORT
MIPS Technologies, Inc.
Phison Electronics Corp.
Redpine Signals, Inc.
RF Micro Devices, Inc.
RICOH COMPANY, LTD.
Rohde&Schwarz
Sanyo Electric Co., Ltd.
Seiko Epson Corp.
Sharp Laboratories of America
silex technology america, Inc.
Silicon Integrated Systems Corporation
Sunplus Technology Co., Ltd.
TES Electronic Solutions
VIA Networking Technology
VinChip Systems
WiLinx Corporation
A-Logics
Adamya Computing Technologies Pvt., Ltd.
Adaptive Labs, Inc.
Advance Data Technology Corporation
Advanced Resources Corporation
Alcor Micro, Corp.
Blind Creek Associates
Cambridge Consultants
CCI Security Group
Centre for Wireless Communications
Clasma Events, Inc.
ComNets, Chair of Communication Networks, RWTH Aachen University
Concentric Technology Solutions, Inc.
Concrete Logic
Datang Microelectronics Technology Ltd.
Electronics Testing Center, Taiwan
ETS Product Service (USA), Inc.
Fractus
Fujitsu Limited
GCTIberica
Globalintech Inc.
Guardian Technologies Pty Ltd
HCL Technologies Ltd
Himico Solutions, Inc.
Homer Technology, Inc
Horner Networks, LLC
Icron Technologies Corporation
Infinite Data Storage Ltd
Interactive Homes, Inc.
J&S Telecoms Int.
J.D. Taylor Associates
La Salle
Lite-On Technology Corp.
LittleAt Pte Ltd.
MET Laboratories
MLWizard
National Institute of Information and Communications Technology
NeoView Technology Inc
Netplan A/S
NTT MCL, Inc.
Omron Corporation
Open Interface North America, Inc.
PeerLink Corp.
Pinpoint Technologies, Inc.
PMTC
Progress Software
Raritan Computer, Inc.
Realtek Semiconductor Corp.
SGS TAIWAN LTD
SkillsUnited
Spansion
Technische Universität München
TecStar Company, MACNICA, Inc.
Teknosarus Embedded Systems
Thales Joint Systems
The Aerospace Corporation
The Ether Group
TRLabs
UMEC
Universidad Publica de Navarra
University of Pretoria
UnWiredConnect Technologies Ltd.
USCredential
Virage Logic
Vistapex Technologies
Winbond Electronics
wiSight, Inc.
Wisme, Inc.
Yokogawa Electric Corporation

IEEE Standardization – Mesh in 802.15

- Task Group since January 2004
- Low & High rate Mesh WPAN
  - Call for Proposals
    - No submissions for low rate received
  - Growing attraction
  - Devices for mass market
  - Fully decentralized
- Addressed topics
  - MAC enhancements
  - Routing
  - Security
- Streaming applications, CE
  - Video
  - Audio
- VoIP

IEEE 802.15.5: Proposal for Mesh WPAN

- Mesh PAN Alliance

  - Joint Philips/ComNets proposal
  - High rate Mesh WPAN
  - Based on WiMedia MAC draft
    - 802.15.3a PHY, WiMedia ≠ DS-UWB
    - Decentralized MAC ≠ 802.15.3
  - MAC enhancements
- Routing & Security by Samsung

Summary

- Mesh technology
  - Important for any wireless system
  - Cost-effective deployment
  - Enabling wireless next generation
- Questions are welcome!

Thank you for your attention!

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