

# **Overview and Status of IEEE 802.11s**

## **WLAN Mesh Networking Task Group**

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Workshop on Carrier Grade Mesh Networks  
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## Overview

### Introduction

- usage scenarios for WLAN mesh networks
- example topologies for WLAN mesh networks

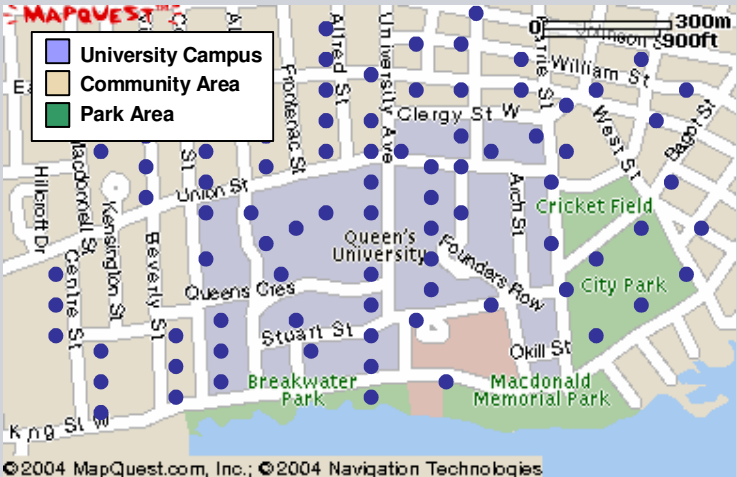
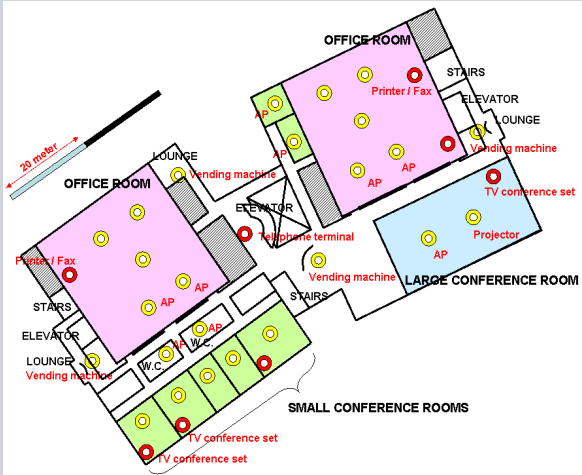
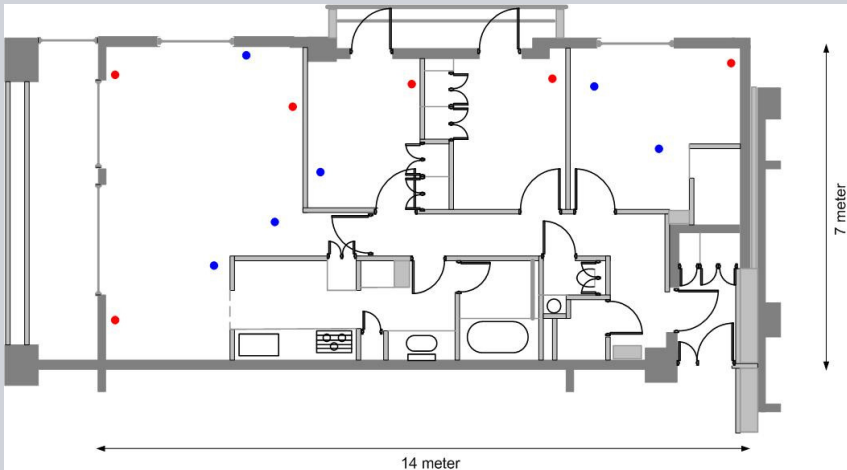
### Major properties of IEEE 802.11s

- Hybrid Wireless Mesh Protocol (HWMP)
- Extensible path selection framework
- 6-address scheme
- Congestion Control
- Mesh Coordinated Channel Access (MCCA)

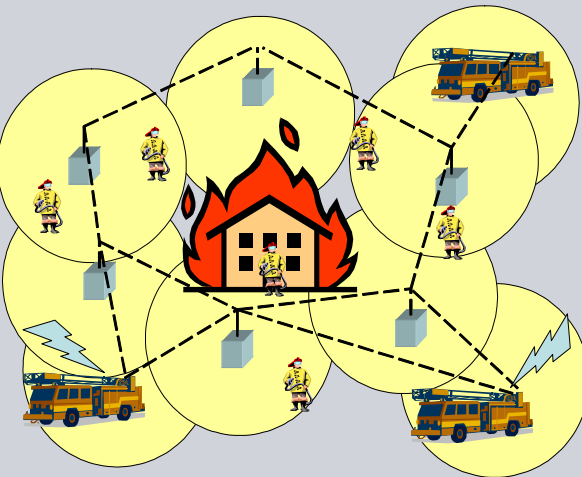
### Status of IEEE 802.11s

### Conclusion: Carrier Grade and IEEE 802.11s

## IEEE 802.11s Usage Scenarios

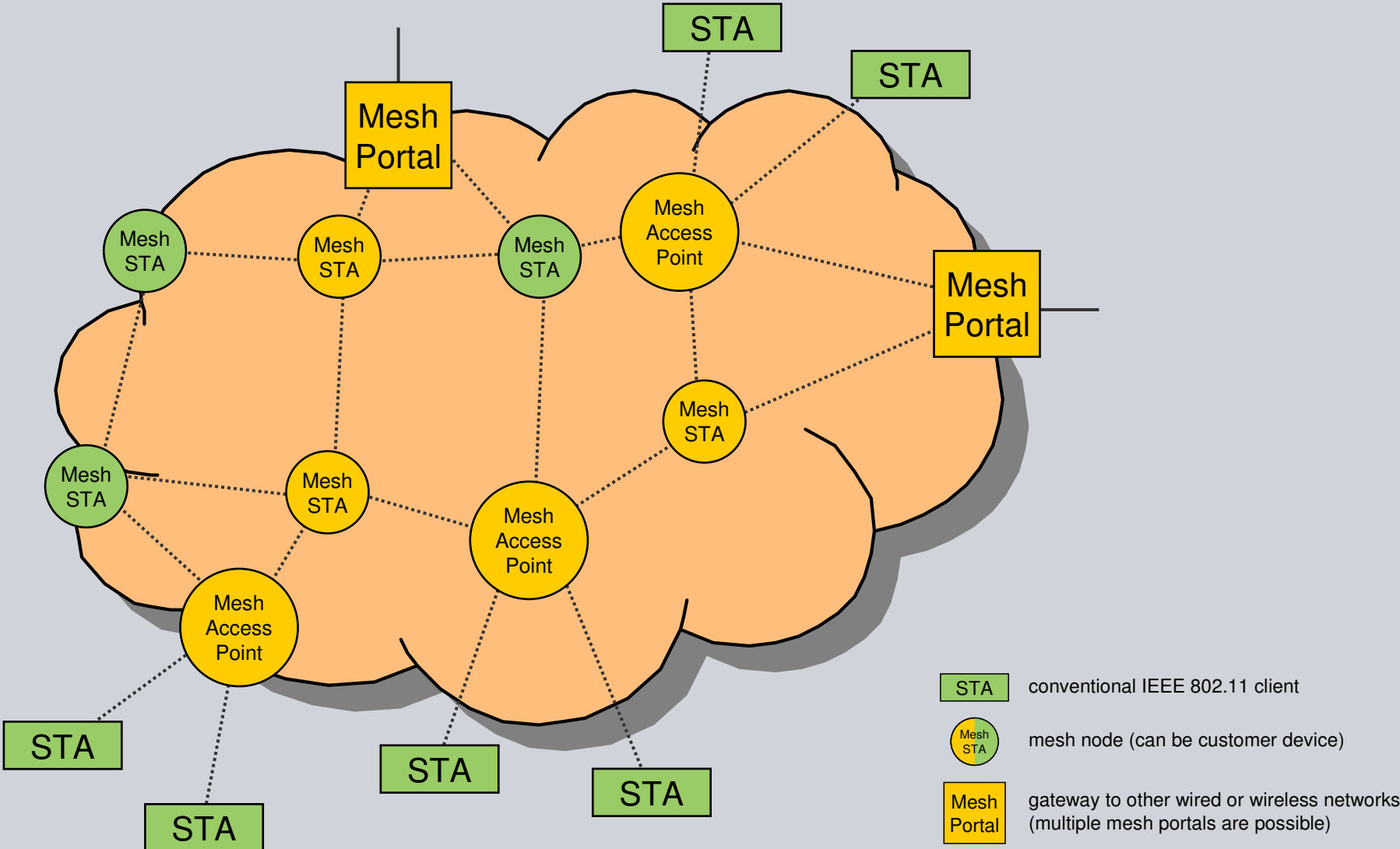


Residential (top), Campus / Community / Public Access (bottom)  
 pictures from: IEEE document 11-04/0662r16



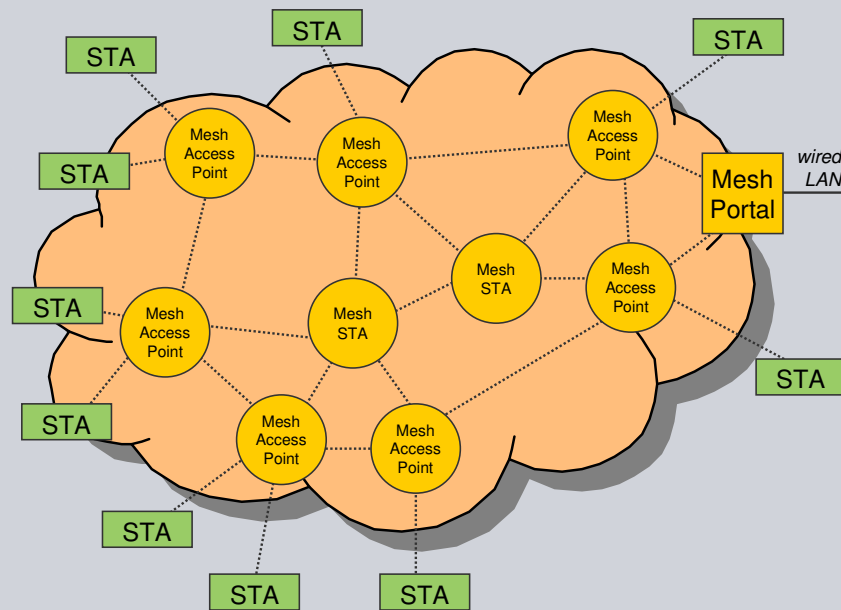
Office (top), Public Safety (bottom)

# WLAN Mesh – A General Example



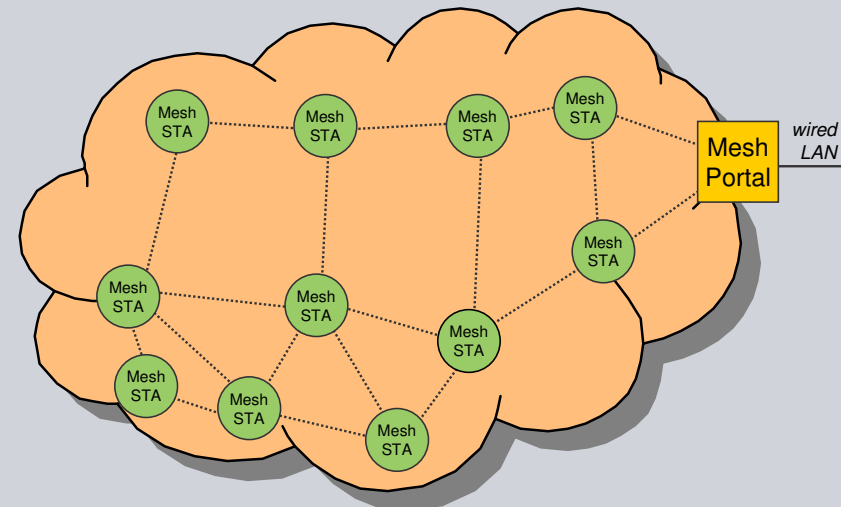
## WLAN Mesh – Backhaul Mesh and Client Mesh

### Backhaul Mesh with Legacy Clients



- STA conventional IEEE 802.11 client
- Mesh STA mesh node (IEEE 802.11s)
- Mesh Portal gateway to other wired or wireless networks (multiple mesh portals are possible)

### Client Mesh



- Mesh STA mesh node (IEEE 802.11s) customer device
- Mesh Portal gateway to other wired or wireless networks (multiple mesh portals are possible)

## Major Properties of IEEE 802.11s WLAN Mesh Networking (I)

MAC address based mesh routing protocol  
⇒ Hybrid Wireless Mesh Protocol (HWMP)

HWMP

Layer 2 routing protocol extensible mesh path selection architecture

Extensible Path  
Selection Framework

radio-aware routing metric  
⇒ airtime link metric

use of WDS 4-address frame or extension

- extension of 4 addresss frame format
- 6-address scheme for IEEE 802.11 mesh data frames

6 Address Scheme

mesh unicast / multicast / broadcast data delivery

- unicast:
  - via paths established with path selection protocol (HWMP)
  - PTK for unicast transmission
- multicast / broadcast:
  - flooding of broadcast frames in mesh network
  - GTK for security

## Major Properties of IEEE 802.11s WLAN Mesh Networking (II)

### time synchronization

- needed for power save and mesh coordinated channel access
- link-local time synchronization

### power save

- needed for battery-powered customer devices, GreenIT
- light sleep and deep sleep modes for different degrees of power save

### mesh coordinated channel access (MCCA)

A rectangular button with a light gray background and a dark gray border, containing the text "MCCA" in a dark gray font.

### congestion control

- congestion control signalling only
- extensibility scheme for more sophisticated congestion control protocols

### compatibility with higher-layer protocols (transparent to higher layers)

- transparent to IP, IEEE 802.1

## Major Properties of IEEE 802.11s WLAN Mesh Networking (III)

support for single and multiple radios

- recommendations for multiple interfaces
- specific solutions are implementation topic

mesh network size: ca. 32 mesh nodes (up to 50 mesh nodes)

- all mechanisms will scale to up to 50 mesh nodes

mesh security: IEEE 802.11i as basis

- IEEE 802.11i for link security
- adaptations for security over mesh backhaul
- Simultaneous Authentication for Equals (SAE) for PSK for client meshes

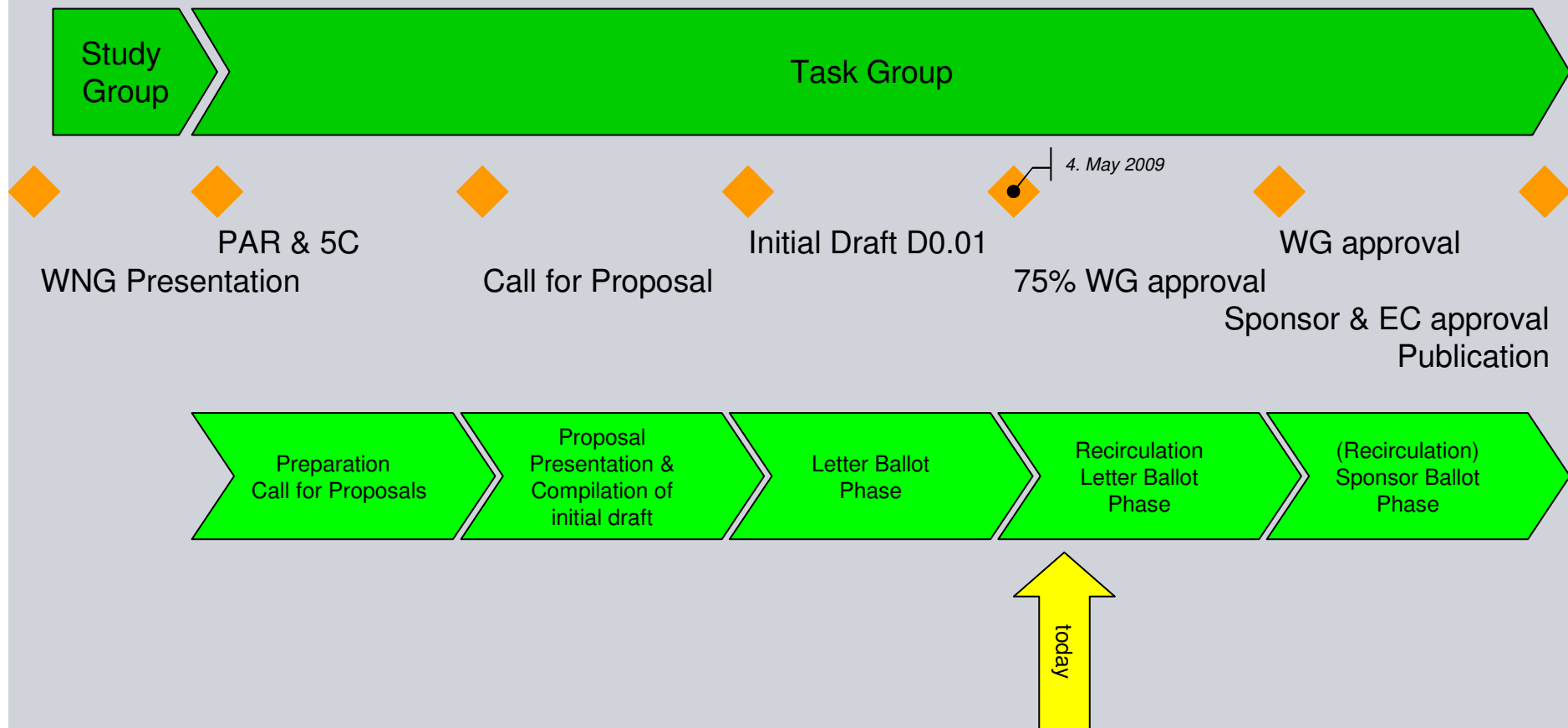
backwards compatibility with legacy BSS and STA

- separation between mesh functionality and AP functionality

no PHY changes required

- done

# IEEE 802.11 Standardization Process



## Status of IEEE 802.11s (WLAN Mesh Networking)

### Proposals

- 15 proposals to IEEE 802.11s in July 2005, includes a proposal by Siemens
- Draft D0.01 in March 2006

### Reviews / Letter Ballots

- Internal Review during April 2006 by Task Group s
- 1st Letter Ballot in December 2006 / January 2007: failed with 48% yes votes, 5714 comments
- 2nd Letter Ballot in April / May 2008: failed with 61% yes votes, 1964 comments
- 3rd Letter Ballot in April 2009: passed with 79% yes votes, 1195 comments, 560 still open

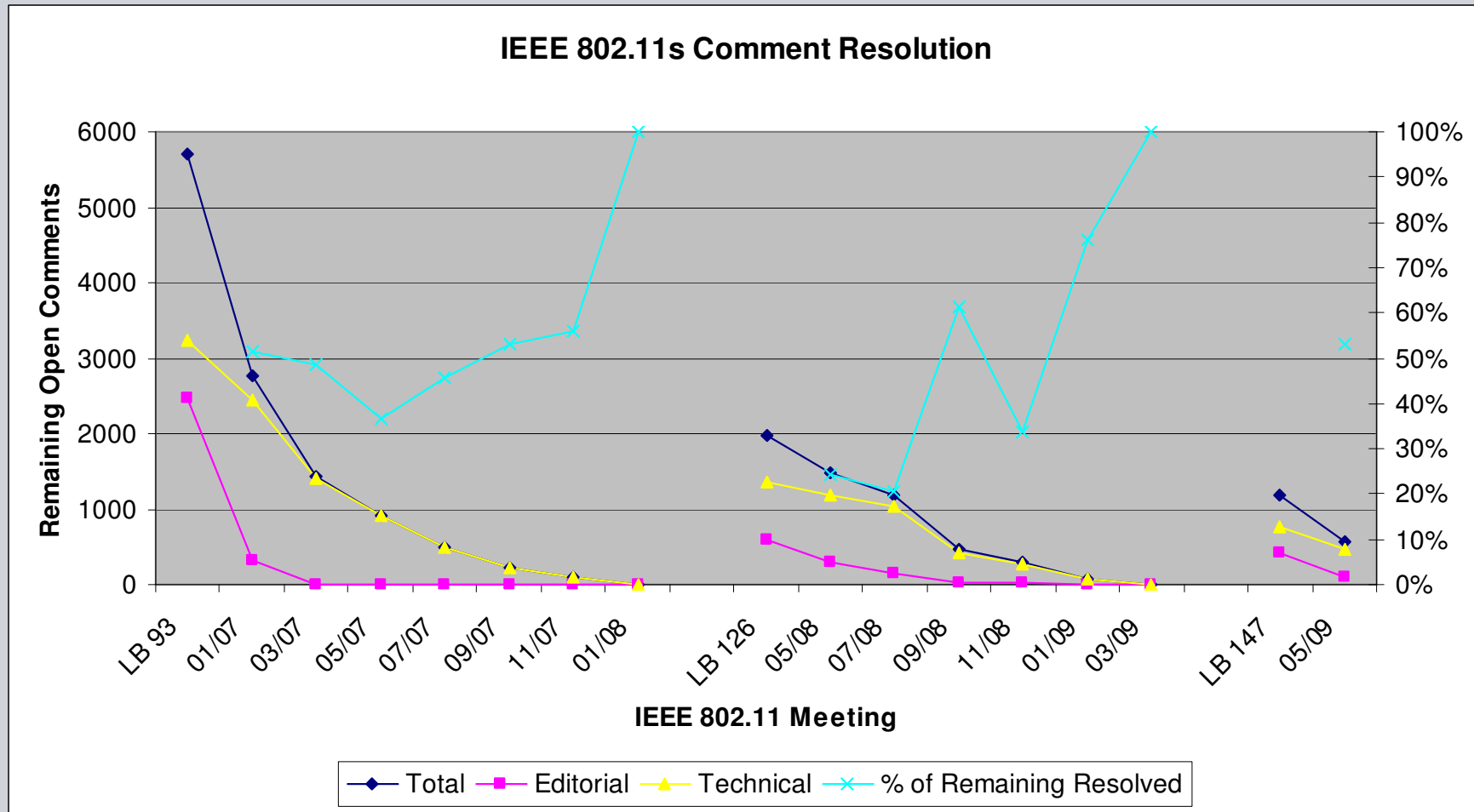
### Technical Content

- AODV + configurable tree to root mesh point with radio-aware metric based on MAC addresses (layer 2 routing protocol)
- extensible routing architecture
- security for transport functionality and authentication with access points (based on 802.11i), pre-shared key based on SAE algorithm (simultaneous authentication of equals)
- synchronization, power save, mesh coordinated channel access, messages for congestion control

### Next Steps

- resolution of comments from letter ballot in Task Group s
- first recirculation letter ballot (Draft D4.0) in July 2009?
- 2010 standard approved

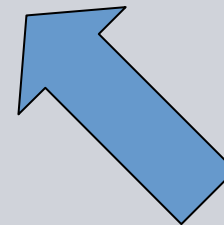
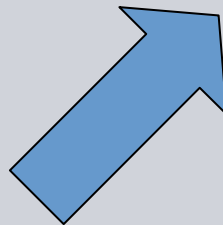
# Comment Resolution Progress in IEEE 802.11s



**Conclusion**

**Carrier Grade Wireless Mesh Networks**

- find acceptable compromises for carrier grade over wireless
- utilize extensibility of IEEE 802.11s for deploying protocols that are optimized for carrier grade services:
  - path selection
  - link metrics
  - congestion control
- good integration of IEEE 802.11s into IEEE 802 networks



**Carrier Grade Services**

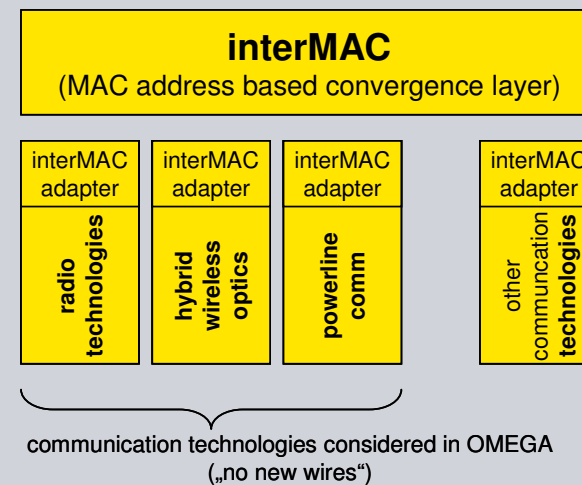
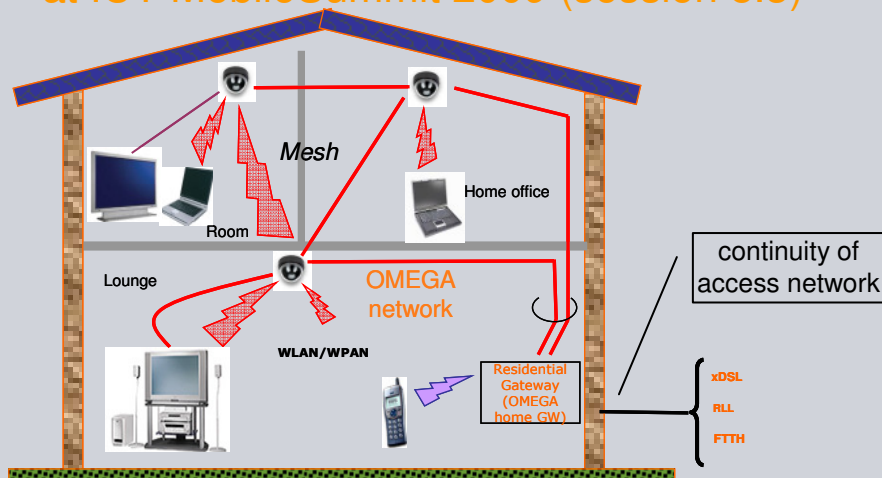
- Reliability:
  - detect & recover from incidents without impacting users
  - most demanding quality and availability requirements (59)
  - rapid recovery time as low as 50ms
- Quality of Service:
  - wide choice & granularity of bandwidth and QoS options
- ...

**IEEE 802.11s WLAN Mesh Networking**

- Wireless: shared medium with dynamic characteristics
- self-organization
  - robust through automatic re-routing
  - low administration effort
- prioritization for QoS (EDCA)
- support for infrastructure networks
- ...

## EU Integrated Project „Omega“

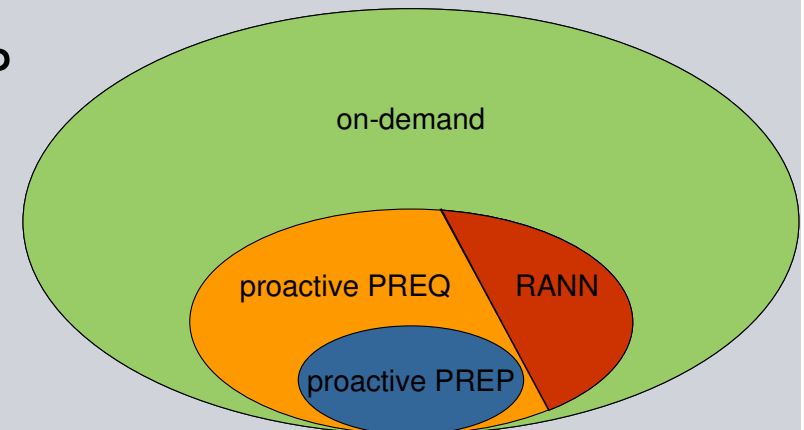
- EU FP 7 Integrated Project with 20 partners from Jan 2008 – Dec 2010
- Ultra Broadband Home Area Networks with transmission speeds of up to 1 Gbit/s via **heterogeneous communication technologies (mesh topology)**
- enrich lives of users (e.g. allowing visual communications, interactive experiences, entertainment)
- support of citizens in maintaining their independence (e.g. offering remote health care, telepresence, advanced communication means)
- simple to install
- **at ICT MobileSummit 2009 (session 8.3)**



**Thank you!**

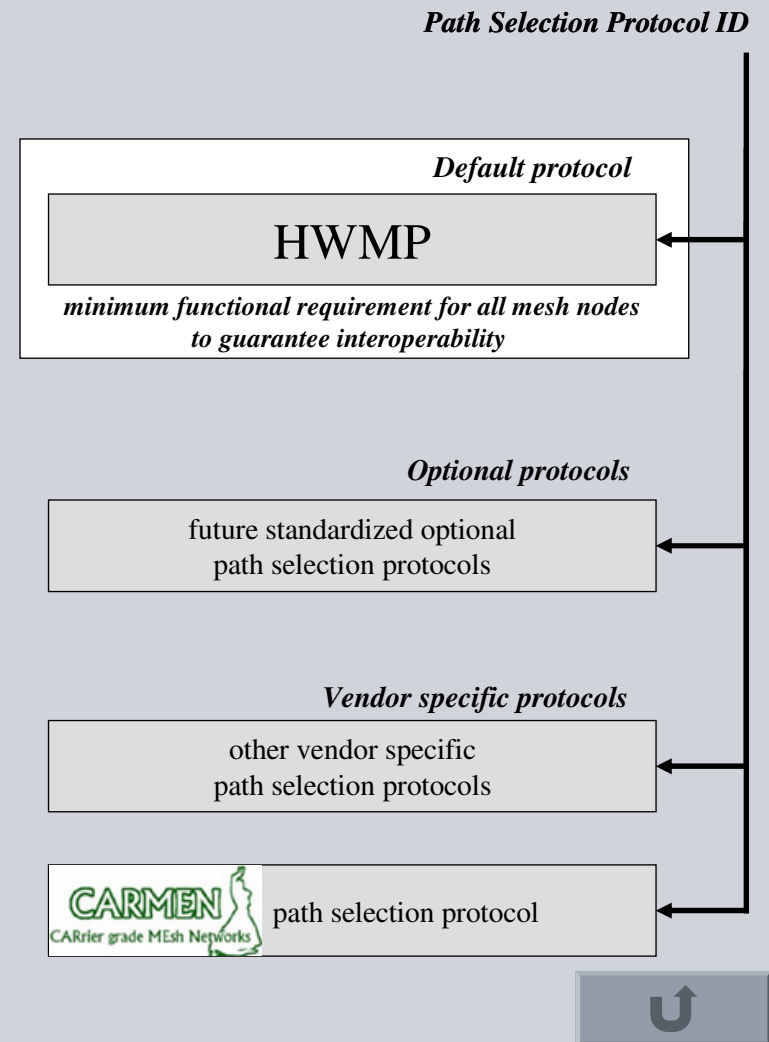
## Hybrid Wireless Mesh Protocol

- Ad hoc On-demand Distance Vector Routing Protocol (AODV) as basis
  - uses MAC addresses
  - works with arbitrary link metrics
  - handles proxy MSTAs
  - always available
  
- Proactive tree to designated MSTAs
  - requires MSTA configured as root MSTA
  - periodic flooding of proactive PREQs or RANNs by root MSTA
  - 3 modes:
    - proactive PREQs – on-demand PREP (no proactive PREP)
    - proactive PREQs – proactive PREP (configured at root MSTA)
    - root announcement (RANNs)

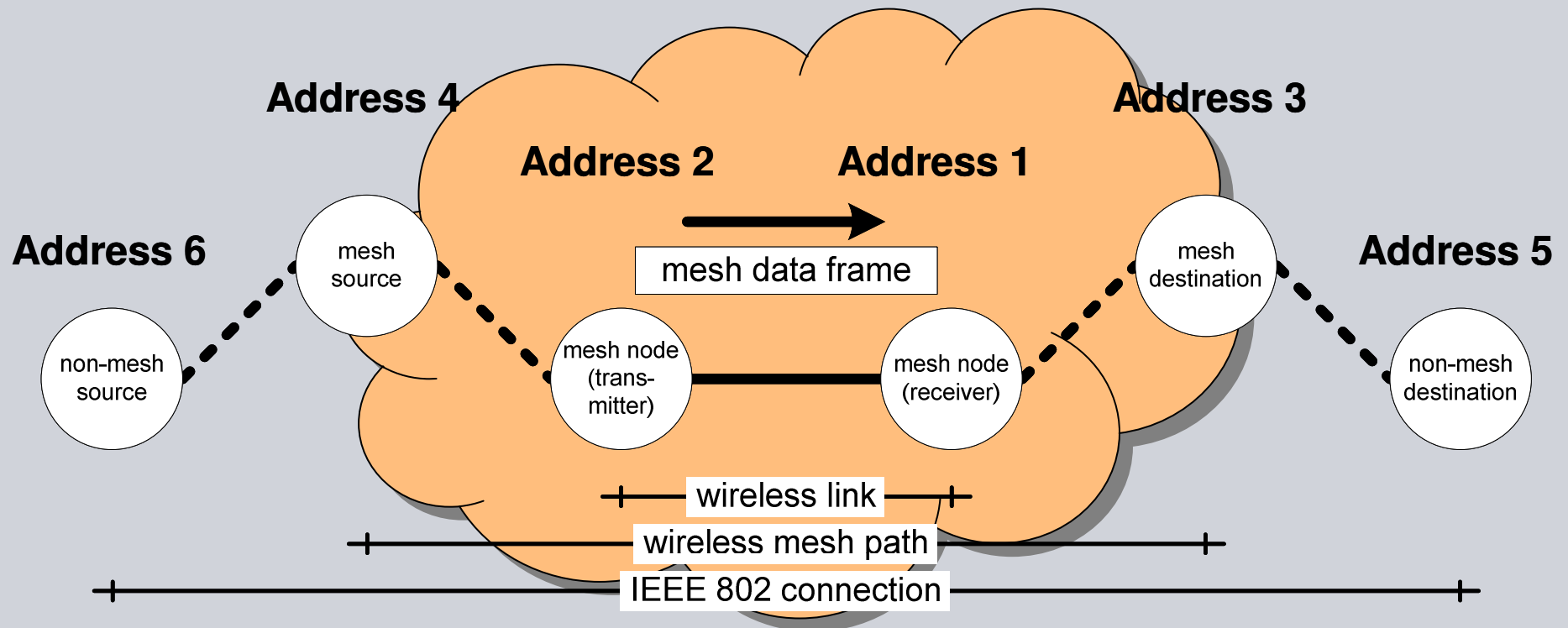


## Extensibility in IEEE 802.11s

- make IEEE 802.11s adaptable to different usage scenarios
- allow the use of vendor specific solutions for routing and routing metrics
- choice of default routing protocol, optional standardized routing protocols, or vendor specific routing protocols
- choice of default routing metric or vendor specific routing metrics
- works over any IEEE 802.11 PHY/MAC (e.g. 802.11n)
- used protocol and metrics announced in mesh identifier



## 6-Address Scheme for Mesh Data Frames



*existence of addresses 5 & 6 indicated by address extension mode setting in mesh data frame*



## Mesh Coordinated Channel Access (MCCA)

- Distributed advance reservation of MCCA opportunities (MCCAOP)
- Reservation:
  - periodicity (# of MCCAOPs per DTIM interval)
  - offset
  - MCCAOP duration
  - set of reservation rules
- MCCAOP Setup Request/Reply, MCCAOP Reservation Teardown, MCCAOP Advertisement
- Interfering times report: consideration of 2-hop neighborhood
- optional mechanism

