An IEEE 802.16/802.11 Hybrid TAN Architecture for the Next-Generation NAS

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Outline

- NAS Background
- 802 Overview
- TAN Approach
  - ✓ Benefits and Concerns
- Areas of Future Work
- Conclusions

NAS Background

- Collection of systems and smaller airspaces to enable air travel
  - Airports, ATCTs, TRACONs, ARTCCs…
- Extensive worldwide growth over past 20-30 years
  - In US, meeting demand for infrastructure has been challenging
  - Gridlock within NAS threatens national interest and economic stability

Current NAS Technology and the NAS Vision

- Largely based on 1960s era
  - Significant upgrades needed for today's NAS requirements
- Current systems "stovepiped"
  - Interoperability largely nonexistent
  - Not intended for integration into a modern communications network
- Contrary to future NAS vision:
  - Transformational "net-centric" NAS
  - Sharing of information, flexible systems, Internet-like capabiliy

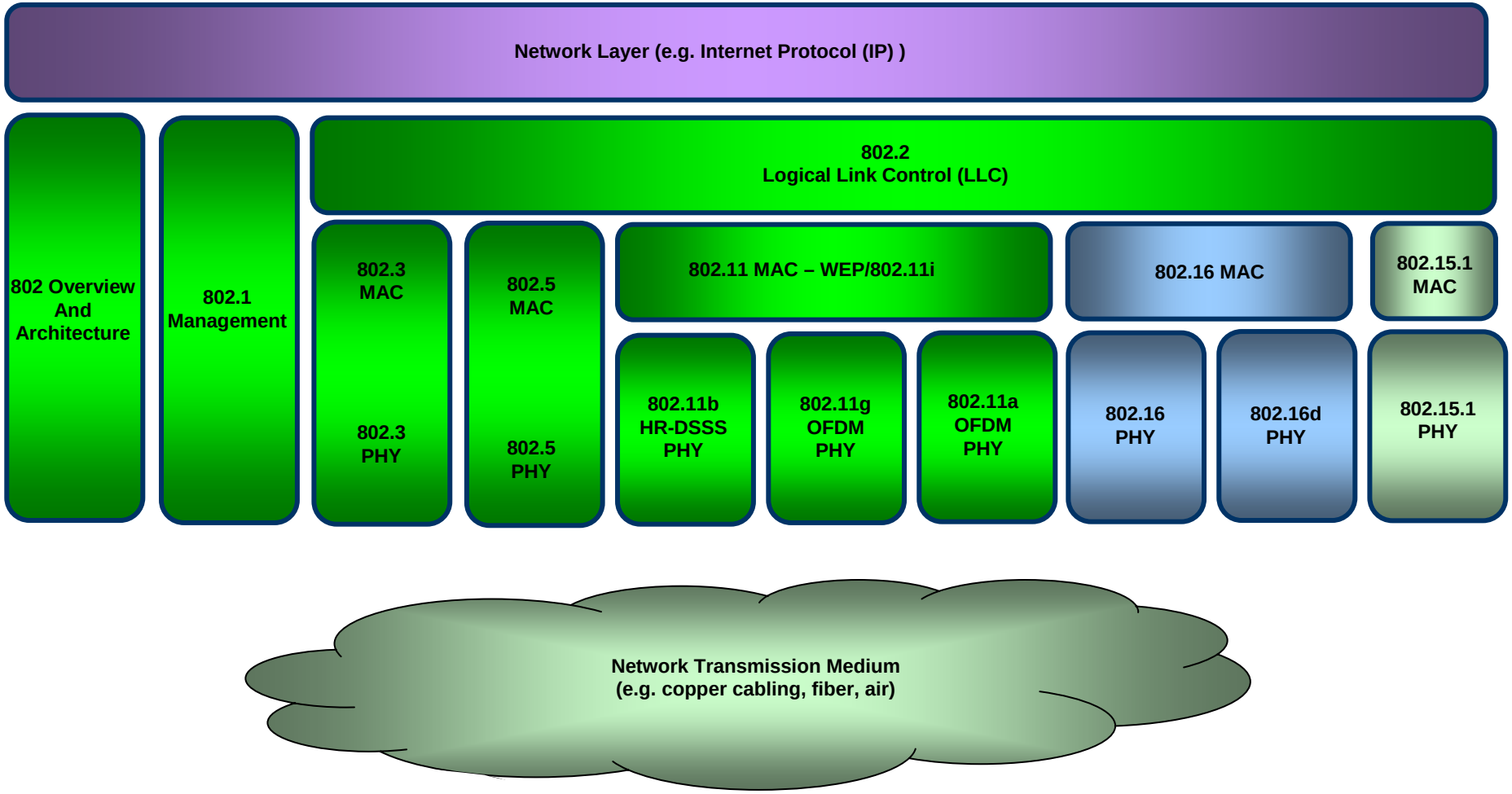
Proposed NAS Network Architecture

- Reliant upon commercial technologies
  - We propose IEEE 802.16/802.11 Hybrid
  - Economy of scale
  - Current success of Internet
  - Demonstrated wireless capabilities
  - Ease-of-use
- However, augmentation likely required
  - Security, mobility and scalability enhancements to support requirements unique to NAS

IEEE 802 Overview

- IEEE 802 is the "Local Area Network (LAN) and Metropolitan Area Network (MAN) standards committee"
  - ✓ Working-group based
  - ✓ Develops PAN/LAN/MAN/WAN standards
    - Ethernet (IEEE 802.3)
    - Token Ring (IEEE 802.5)
    - Wireless Local Area Networks (LAN) (IEEE 802.11)
    - Wireless Personal Area Networks (PAN) (IEEE 802.15)
    - Broadband wireless networks (IEEE 802.16)
    - Mobile broadband wireless networks (IEEE 802.20)

IEEE 802 Family



NOTE: Non-exhaustive view of the IEEE 802 technology family

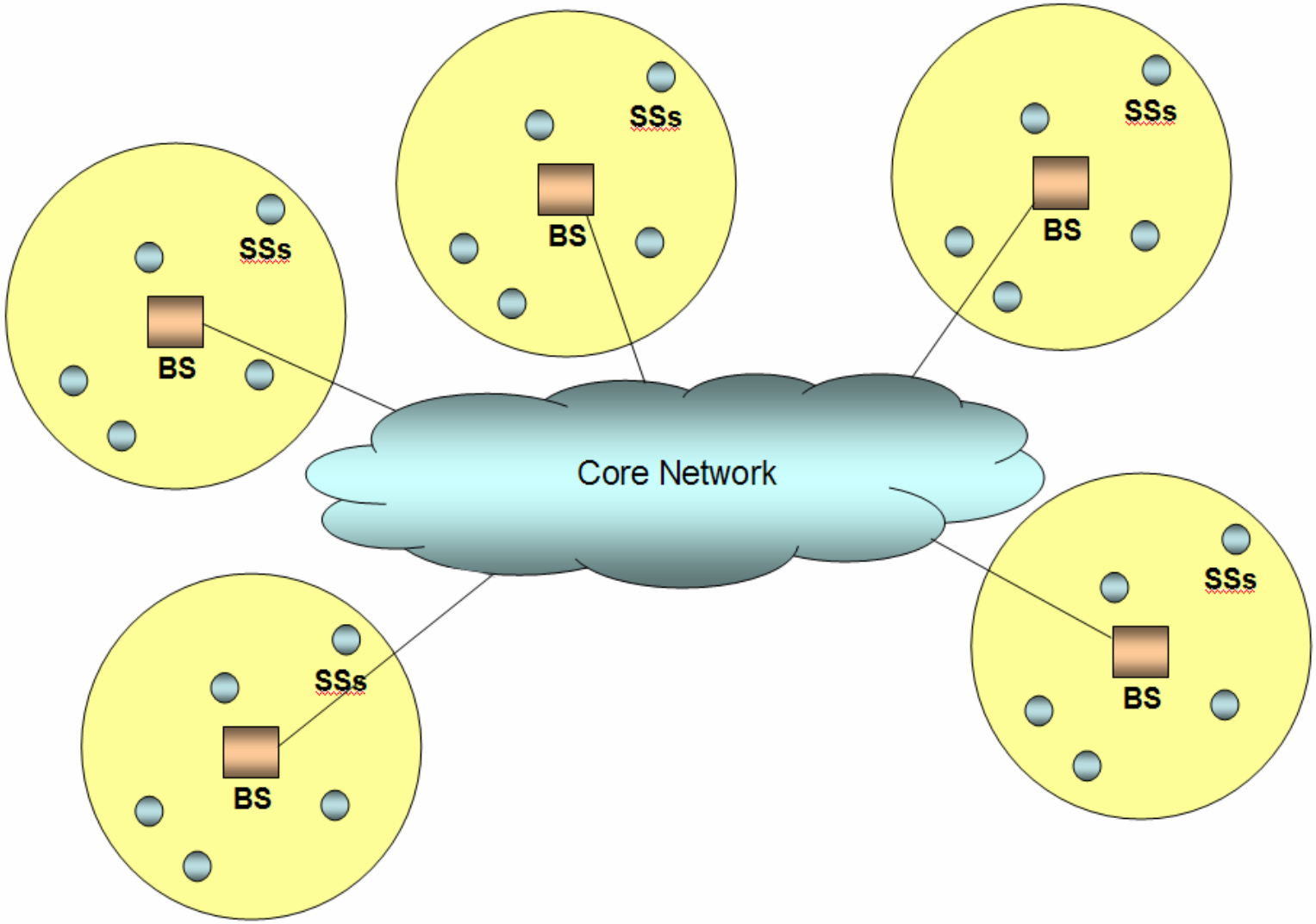
802.16 Overview

- IEEE 802.16 WG responsible for developing WMAN standards
  - Definition of PHY and MAC layers
- Also termed “WiMAX”, though…
  - WiMAX is a consortium that certifies products and ensures interoperability based upon “profiles”.
  - WiMAX is *not* the standard itself

Various 802.16 Flavors

Specification	Year of Ratification	Description
802.16	2001	MAC and PHY definition for fixed broadband wireless access in the 10-66 GHz frequency bands
802.16a	2003	Amendment to the original specification, contains new PHY definitions for the 2-11 GHz frequency bands. Also includes mesh network modes of operation
802.16c	2002	System profiles for 10-66 GHz operations
802.16d	2004	Contains 802.16, 802.16a, and various MAC enhancements. Also referred to as 802.16-2004, it is considered the base 802.16 fixed broadband wireless specification
802.16e	2006	Amendment to the 802.16d specification to provide explicit support for mobility.
802.16f	In Progress	802.16 Management Information Base (MIB)
802.16g	In Progress	Network Management (management plane control procedures)
802.16h	In Progress	Coexistence in license exempt frequency bands
802.20	In Progress	Mobile broadband wireless access standards group.
WiBRO	N/A	Korean wireless broadband standard that will be incorporated into the upcoming 802.16e standard

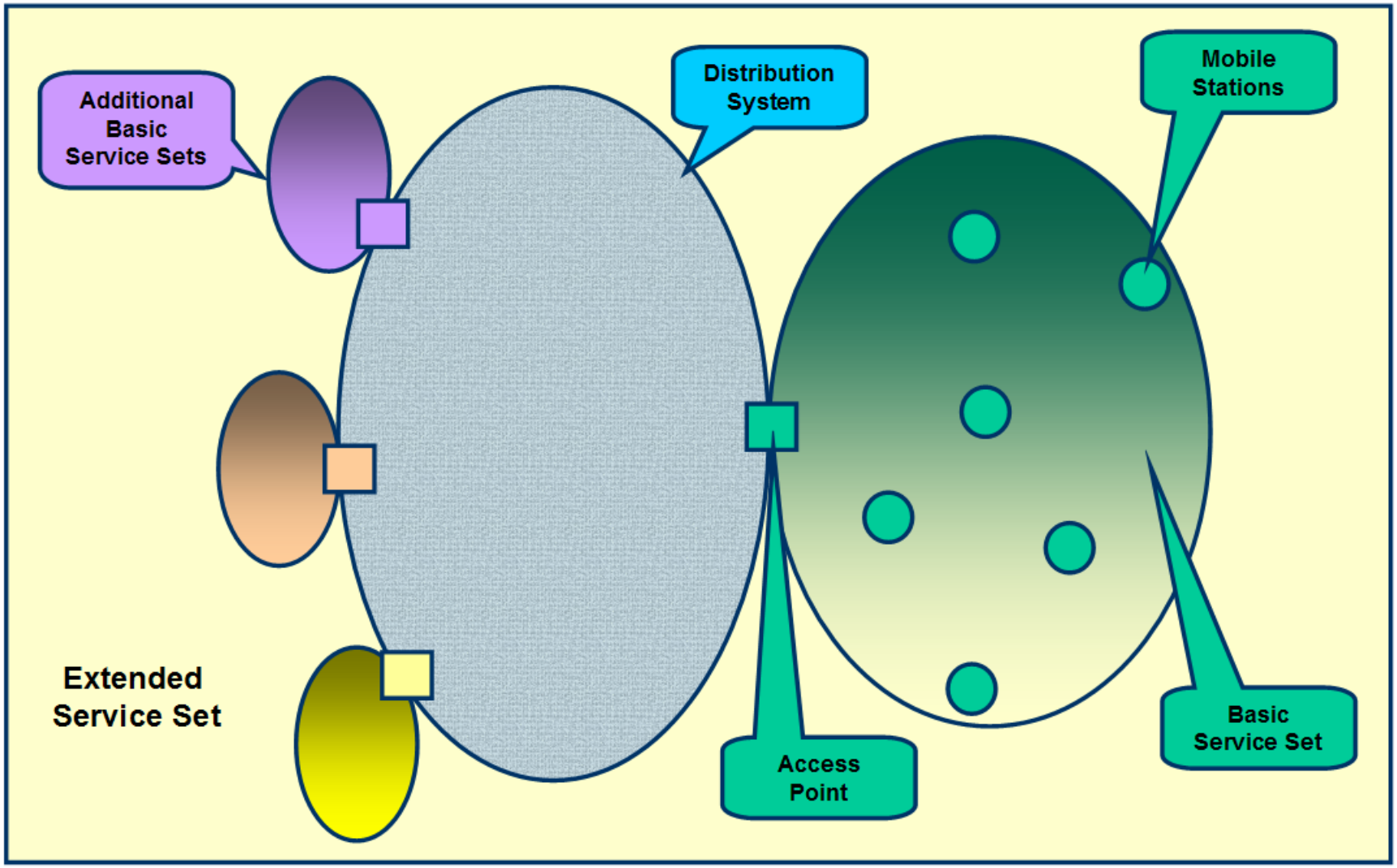
Conceptual view of 802.16 Net



802.11 Overview

- IEEE 802.11 WG tasked with developing standards for WLAN
  - Definition of PHY and MAC layers
- "Wi-Fi" Alliance responsible for certification
- "Task Groups" define different PHY implementations of the protocol, clarifications to current IEEE 802.11x standards, address Quality-of-Service (QoS), and security, among other issues.
- Common to the entire IEEE 802.11 Group:
  - MAC Task Group: Defines the common IEEE 802.11 MAC which is compatible with all PHY implementations
- Currently implemented Wireless LAN Standards:
  - Task Group A: PHY at 5.2 GHz using OFDM (up to 54 Mbps)
  - Task Group B: PHY at 2.4 GHz using DSSS (up to 11 Mbps)
  - Task Group G: PHY at 2.4 GHz using OFDM (up to 54 Mbps)
  - Task Group I: Security and Authentication Enhancements
  - Task Group N: Throughput Enhancement using MIMO (100+ Mbps)

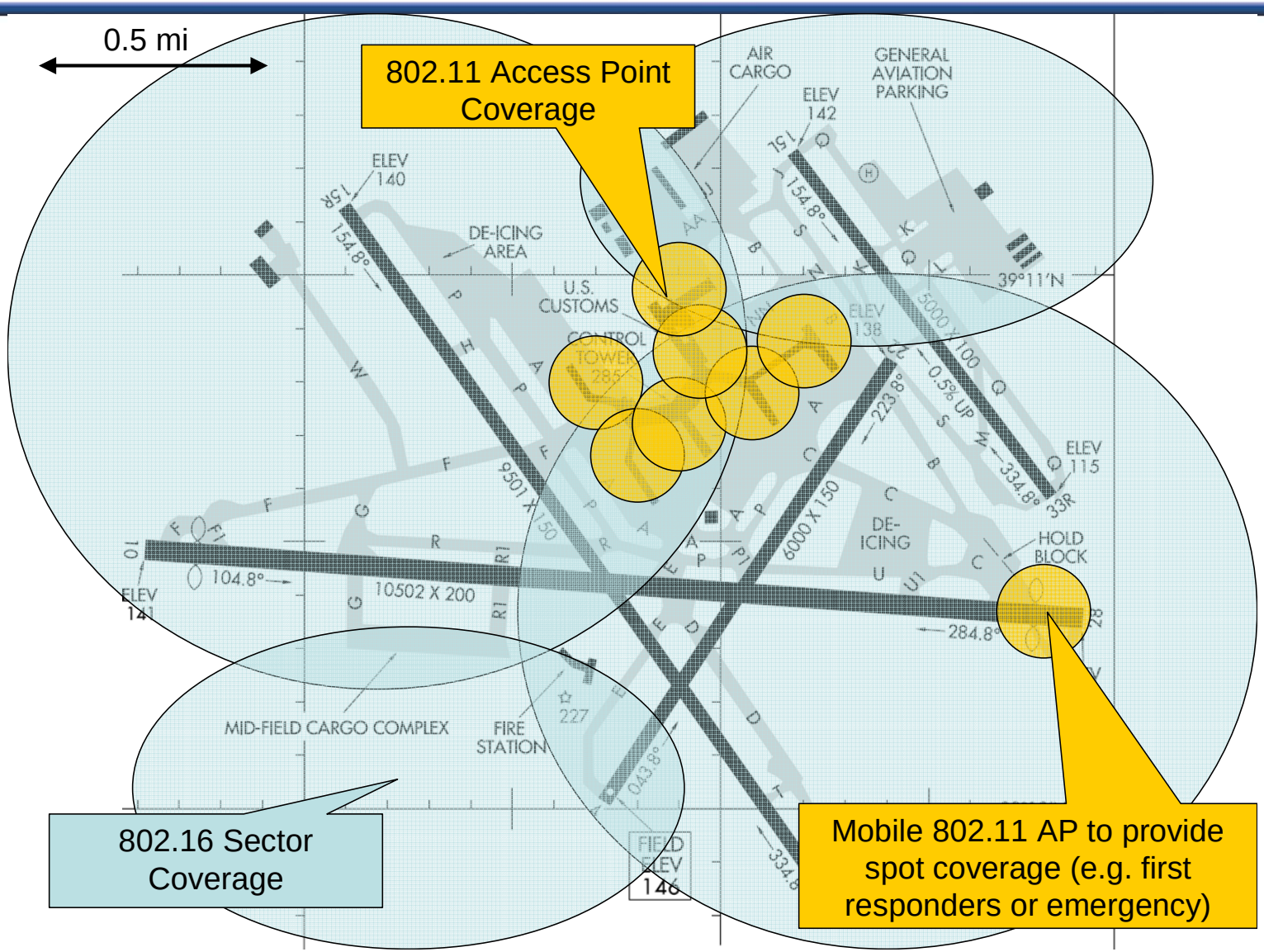
802.11 Network View



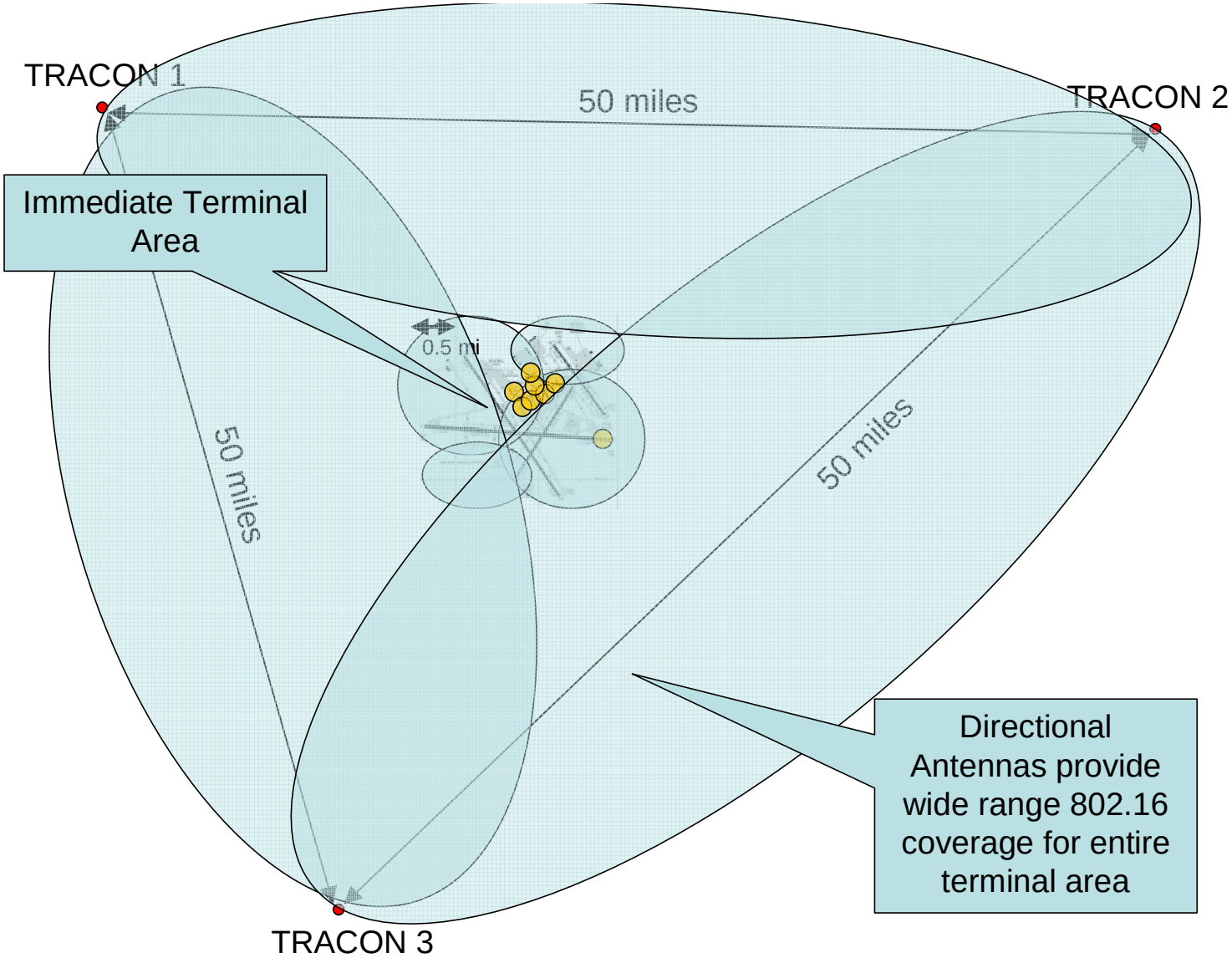
Proposed TAN Architecture

- An IEEE 802.16/802.11 Hybrid
  - ✓ Task Group E: QoS Support
  - ✓ 802.16 functions:
    - High data rate (1 Mbps-2 Mbps) Airport-wide coverage, connectivity between TRACONs, altitude coverage up to 5000 ft with support for mobility
  - ✓ 802.11 functions:
    - Higher data rate (11 Mbps-54 Mbps), immediate terminal area coverage (gates, baggage claim), ad-hoc coverage as needed in remote airport areas (e.g. first responders), no altitude coverage

BWI Airport Example



BWI Airport with TRACONs



Required Platform Infrastructure

Infrastructure Platform Type	Purpose	Number Required
IEEE 802.16d Base Station	Airport Property-Wide Coverage	4-6
IEEE 802.11g Access Point	Localized High Data Rate Coverage	7-21

Envisioned User Platforms

User Platform Type	Applications
Airplane	Air Traffic Control Data Weather Data Voice and Video from/to Cockpit Airplane Diagnostics and Automated Maintenance
First Responder Teams	High Priority Voice and Video Traffic
Airline Agents	Voice Traffic Corporate Airline Network Access
Security Agents (e.g. TSA and other Federal Agents)	Video Surveillance Voice
Business and Personal Users	Wireless Internet Access

Benefits

- Highly scalable
- Open standards
  - ✓ Reduced deployment time, more cost-effective
  - ✓ Future technology enhancements
- QoS support
  - ✓ Enables user class differentiation

Weaknesses

- Security mechanisms
  - Terminal Area requires unique security to protect air travelers
  - Expected that current security mechanisms within 802 standards do not meet needs of HS/TSA users
- Complexity of 802.16
  - Optimization for the Terminal Area scenario may take time
- Mobility support
  - 802.16e expected to support vehicular users, not airborne
  - Performance TBD. May require future enhancements for airborne platforms

Areas of Future Work

- Mesh Networking
  - Mobile users act as relays, reducing the infrastructure requirements as they become part of it
- Automated Network Management
  - Reduces the need for human-in-the-loop operations and maintenance
- Security Enhancements
  - As 802 standards evolve and security becomes mainstream, expected that augmentations in this area will be minimal
- Data Rate Enhancements
  - 802.11n and future 802.16 enhancements will increase PHY layer data rates
- Throughput Enhancements
  - 802.11 future will provide MAC layer enhancements to existing 802.11 MAC, from 60% efficiency to 90% efficiency
- Certification
  - New aviation networks must go through rigorous certification at the FAA. Any approach using IEEE 802 technology would require such certification, including an extensive analysis and assessment process.

Conclusions

- Enormous growth of the NAS requires a flexible, scalable network infrastructure to support the future NAS net-centric vision
- We propose a promising hybrid IEEE 802.16/802.11 TAN architecture as a highly capable way to support this vision
- Augmentations in areas of security and mobility support may be needed to support the specific platforms and users of the TAN