802.11e QoS

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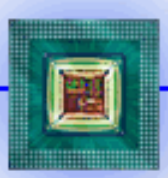
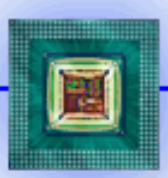
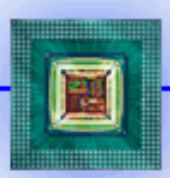


Agenda

- 802.11 standards overview
- Wireless QoS principles
- The draft 802.11e standard supplement
- Applications of 802.11e

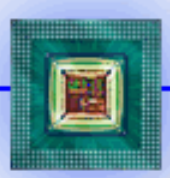


802.11 standards overview



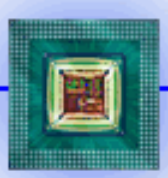
802.11 standards overview

- IEEE 802.11-1997 base standard
  - ◇also released as ANSI/ISO 8802-11 1999
- Standard supplements extend the base standard
  - ◇802.11a, b, c and d already approved
  - ◇802.11e, f, g, h and i under development in the IEEE 802.11 working group



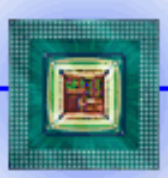
802.11 supplements glossary

- 802.11a – 5GHz OFDM PHY layer
- 802.11b – 2.4GHz CCK PHY layer
- 802.11c – bridging tables
- 802.11d – international roaming
- 802.11e – quality of service
- 802.11f – inter-access point protocols
- 802.11g – 2.4GHz OFDM PHY
- 802.11h – European regulatory extensions
- 802.11i – enhanced security

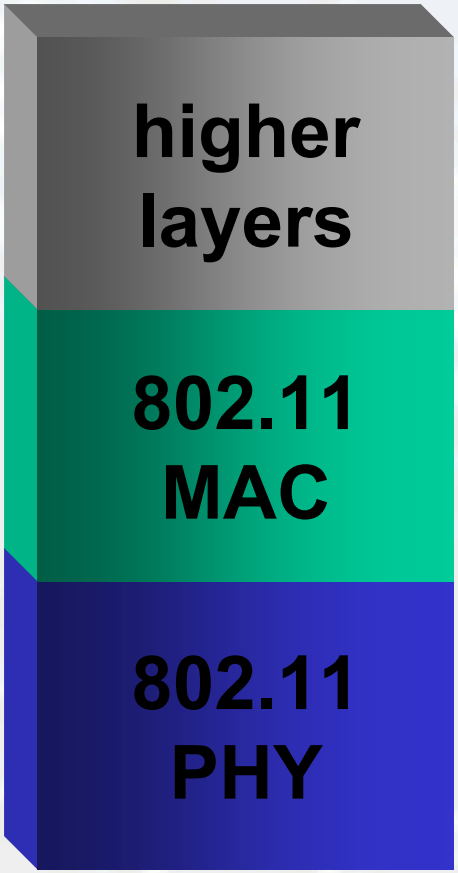


802.11 standard & supplements

- Base standard divided into two layers
  - ◇ medium access control (MAC) layer
  - ◇ physical (PHY) layer
- Standard supplements extend one of these layers or provide higher layer functions
- Supplements at different layers can be intermixed
  - ◇ 802.11e applies to 802.11b, 802.11a and 802.11g



802.11 standards

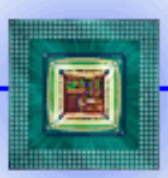


supplements 802.11c and 802.11f

supplements 802.11d, 802.11e, 802.11i and 802.11h

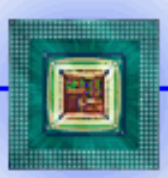
supplements 802.11a, 802.11b and 802.11g

Wireless QoS principles



Wireless QoS principles

- What works in a wired network doesn't necessarily work in a wireless network
  - ◇too many broken assumptions
- System aspects
  - ◇division of functions across layers
  - ◇application expectations

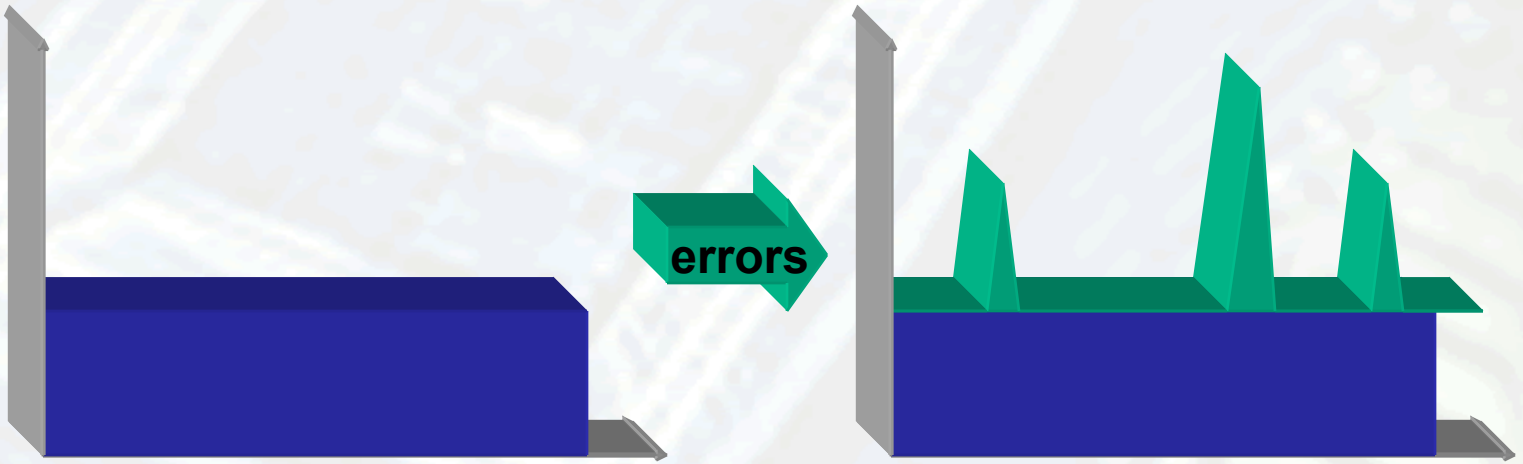


The INWS* principle

- Many previous attempts at WLAN QoS (and non-QoS channel access schemes), show that strategies that work well in a wired environment don't translate to WLAN
- Things that break assumptions:
  - Packet error rate can be in the range 10 – 20%
  - Bit rates vary according to channel conditions – you can't do a bandwidth reservation at connection setup time and expect it to stick
  - The "rubber pipe problem" – a bandwidth manager doesn't know how much bandwidth it has to manage, since a neighboring, unrelated bandwidth manager can take some of it at any time
- Questions:
  - what does "guaranteed QoS" mean in a system with a 20% packet error rate?
  - what does "connection admission control" mean in an unlicensed RF band?

***it's not a wire, stupid**

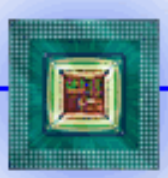
CBR traffic in a wireless LAN



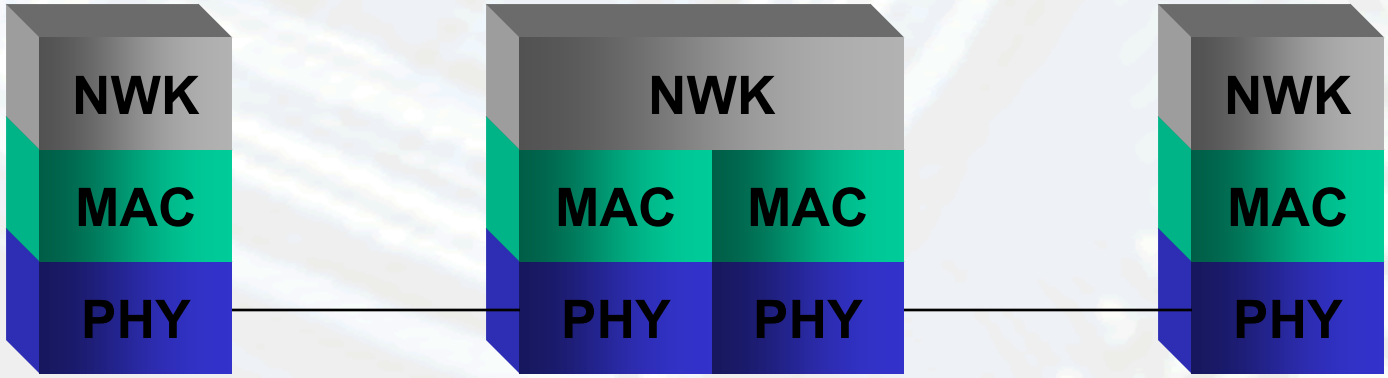
- Multimedia traffic is frequently modeled as predictable, constant bit rate
  - ◇ but CBR traffic acquires a significant bursty component in the presence of packet errors that force retries
  - ◇ constant slot allocation strategy alone does not work well any more

System aspects

- Not all functions need to be contained in the MAC layer
  - ◇ 802.11e targeting Ethernet equivalence
  - ◇ connection admission control considered a higher layer problem
  - ◇ MAC needs only to provide priority separation
- Different applications make different assumptions about connection admission control
  - ◇ 802.11e targeting all of these applications



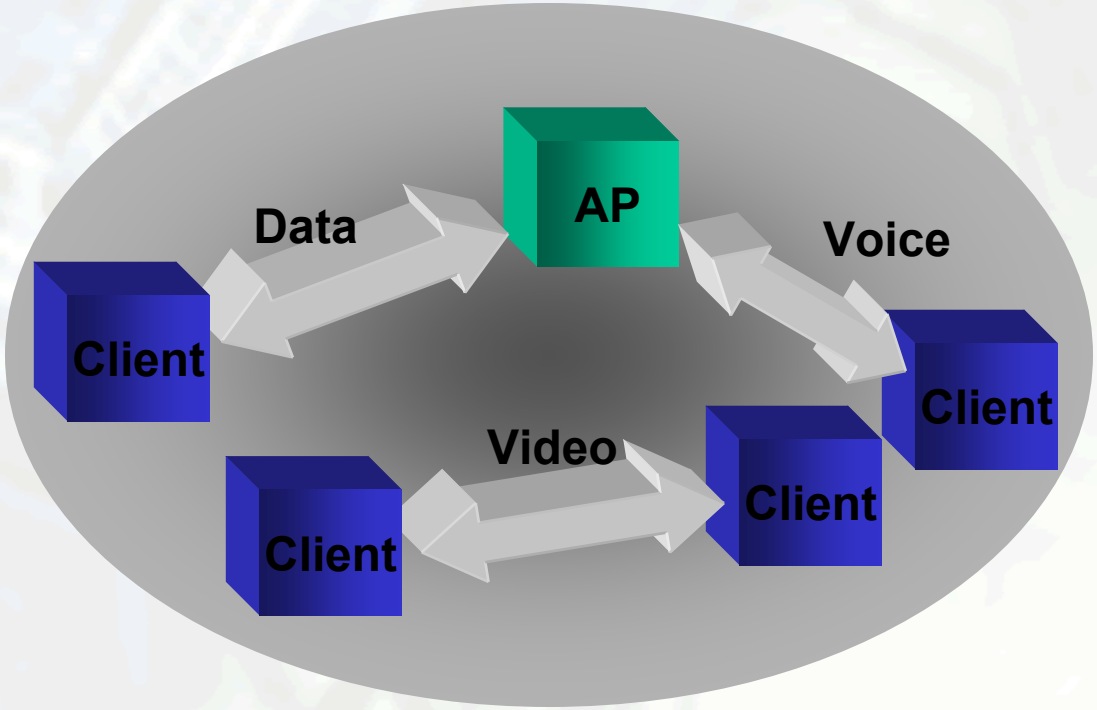
Division of functions across layers



- MAC layer can only see its own network segment
- Connections are end to end, and not in the domain of the MAC
- Packets that are part of a stream are labelled with a priority and passed to the MAC

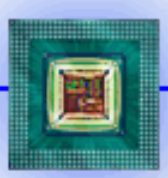
Example usage

- Voice call is highest priority, gets lowest latency
- Video is next priority, will get sufficient bandwidth if it is there
- Data will get whatever bandwidth is left over



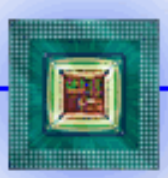
Bandwidth Reservation

- Also referred to as connection admission control
- IP-based networks typically use RSVP for this function…
- …but in practice, most applications don't bother
  - IP-based applications are designed to be robust to changes in conditions
- Industry is moving away from RSVP
  - RSVP is no longer supported in Microsoft Windows XP

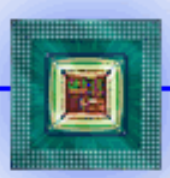


Implications for 802.11e

- 802.11e must support 802.1D priority marking
  - ◇makes its behavior identical to Ethernet
- 802.11e cannot assume that RSVP is present
  - ◇but can be designed to take advantage of additional information if it is there

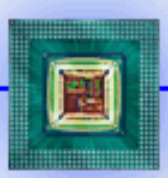


The draft 802.11e standard supplement



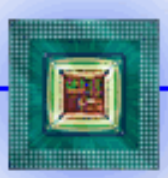
The draft 802.11e standard supplement

- Focused on two applications:
  - A/V capability for consumer devices – need to handle at least three simultaneous DVD rate MPEG-2 channels, or one HDTV rate MPEG-2 channel, with a quality that passes the “super bowl test”, over 802.11a
  - Managed QoS for corporate networks – provide prioritization that integrates with network management infrastructures
- Backwards compatible with existing systems; non-802.11e stations operate as best effort
  - consumers will still want to take their laptops home from work, and will expect to access multimedia applications
- Any solution *must* address both of these



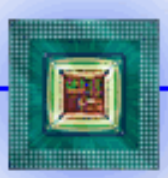
Previous attempts at WLAN QoS (1)

- Hiperlan 1 (EY-NPMA)
  - ◇early (1996) fully distributed prioritized scheme
  - ◇focused on time bounds rather than 802.1p-style flow separation
  - ◇theoretically highly efficient and delivers on time bounds, but fragile in presence of errors and hidden stations



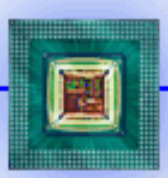
Previous attempts at WLAN QoS (2)

- Hiperlan 2 (Wireless ATM)
  - ◇ fully centralized – all scheduling pushed to the AP, which broadcasts time allocation for each 2ms superframe
  - ◇ theoretically highly efficient, given a perfect scheduling algorithm (nearly all publicly available papers assume this)
  - ◇ efficiency drops dramatically in adverse (bursty) traffic conditions, because efficiency is dependent on ability of scheduler to predict requirements
  - ◇ immensely complex



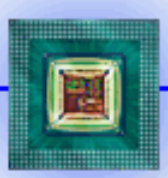
Previous attempts at WLAN QoS (3)

- HomeRF (DECT/802.11)
  - ◇combines CSMA/CA for data, slots with retransmission for voice
  - ◇works well within stated objectives – efficient data transfer, good for voice, but doesn't cater for video
  - ◇let down by inadequate PHY layer



802.11e HCF

- Different solutions have been shown to work well for different classes of traffic
- 802.11e introduces a new concept of the “hybrid coordination function”
- Single channel access protocol that has elements of polled and CSMA based channel access



802.11e Hybrid Strategy – the Best of Both Approaches

CSMA/CA

- Most efficient, lowest latency for bursty traffic
- Per-packet channel access overhead, not exploiting optimization opportunity for predictable traffic

Point Coordinated

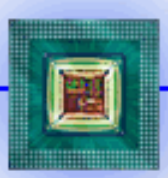
- Per stream channel access overhead, larger than CSMA per-packet overhead, but more efficient for predictable traffic
- Very inefficient with bursty traffic; scheduler assigns slots in the wrong places due to mispredictions

802.11e

- "Hybrid Coordination Function" uses both techniques
- Short point-coordinated bursts provides efficient channel access for data that the coordinator can predict
- CSMA provides efficient access for bursty traffic, retransmissions

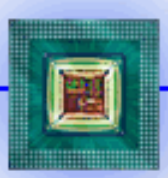
802.11e side traffic

- 802.11-1997 specification permits traffic in an AP-based network between clients and AP only
- 802.11e adds capability for clients to send traffic directly to each other
  - ◇improves bandwidth efficiency, particularly in home networks



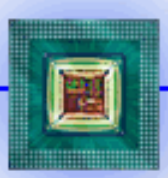
How 802.11e supports applications

- Extended 802.1D priorities
- Supports standard 802.1D (802.1p) priorities 0 to 7
- Also includes “traffic streams”
  - ◇ if RSVP is in use, and can set up specific parameters, these can be passed to the MAC and are bound to a traffic stream identifier, 8 to 15
  - ◇ that tag is then reserved for that specific connection



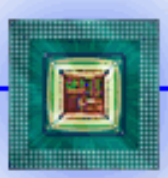
802.11e signaling (1)

- Two forms of signaling for traffic originating at clients
- “Queue state indicator” based on measurements of arrival rates
  - ◇ connectionless, supports 802.1D priority
  - ◇ notification only – not a negotiation
  - ◇ provides data to poll scheduler at AP

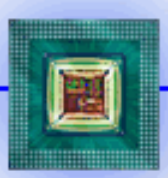


802.11e signaling (2)

- "Traffic Specification" based on RSVP or other higher-layer protocol
  - ◇ "shadow connection setup" mirrors higher layer
  - ◇ MAC-layer negotiation
  - ◇ provides more precise data to scheduler

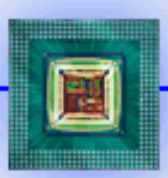


Applications of 802.11e



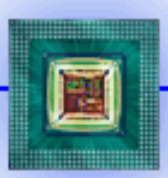
Applications of 802.11e

- Focus on two usage models:
  - IP-based multimedia
  - 1394 over 802.11a

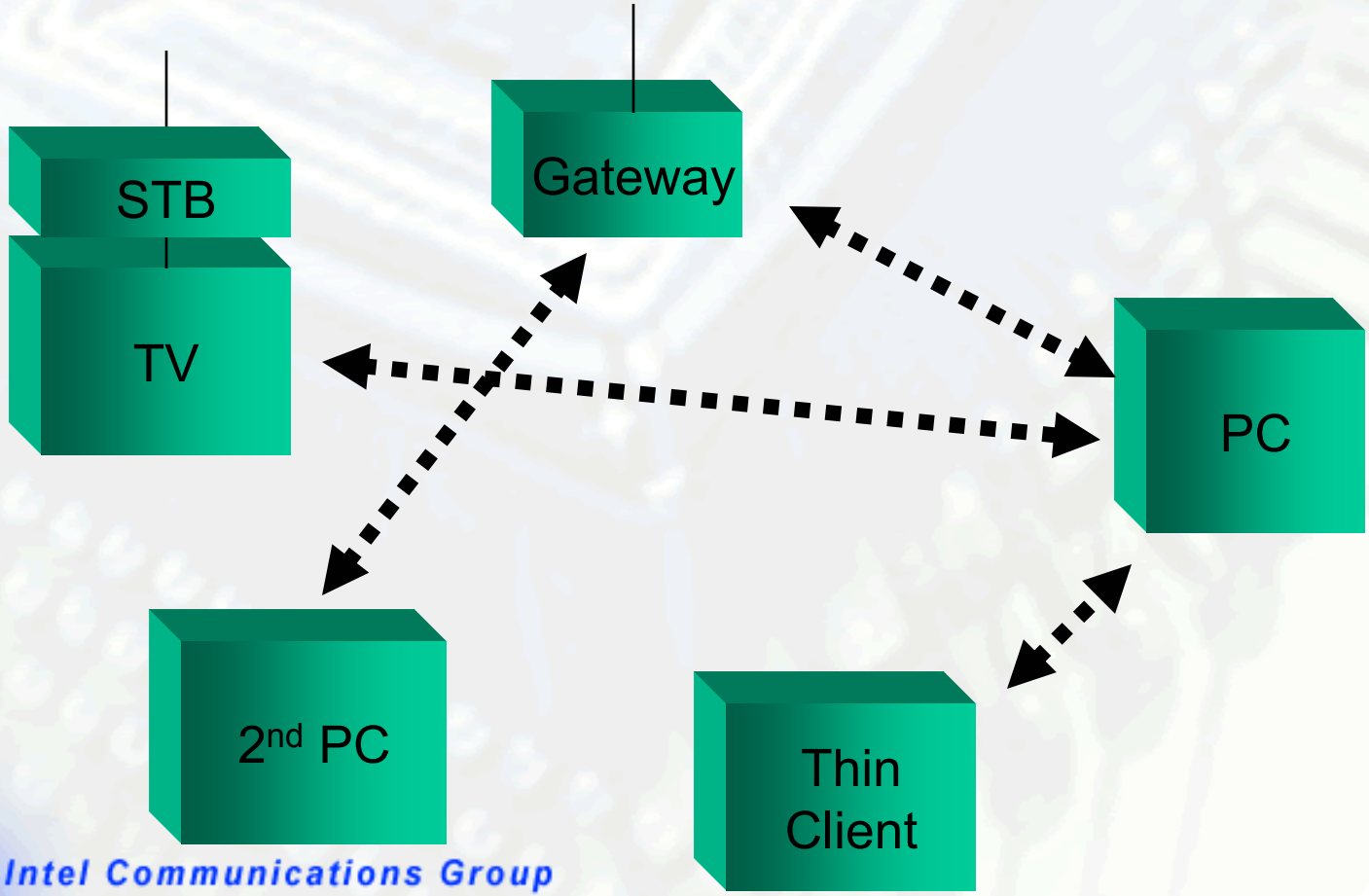


IP-based multimedia

- Streaming protocols such as RTP/RTCP
- Applications have been built on the assumption of very little guarantee of service from the network
- Robust to sudden changes – built in adaptability
- Require only on 802.1D-based priority, where available
- Seamless bridging across Ethernet and 802.11

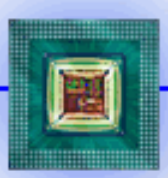


IP-based multimedia in the extended PC home (1)



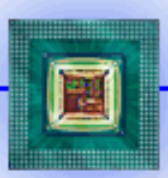
IP-based multimedia in the extended PC home (2)

- 802.11e supports high quality streaming media between PCs, gateways and extended PC devices
- Media store and personal video recorder implemented on PC
- TV or other rendering device can use the wireless network to access mutiple media sources



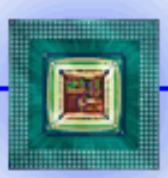
IP-based multimedia in the extended PC home (3)

- Thin client (such as a webpad) can be used to:
  - ◇preview video from a media store (PC) or other media sources
  - ◇run remote desktop from PC
  - ◇access the Internet

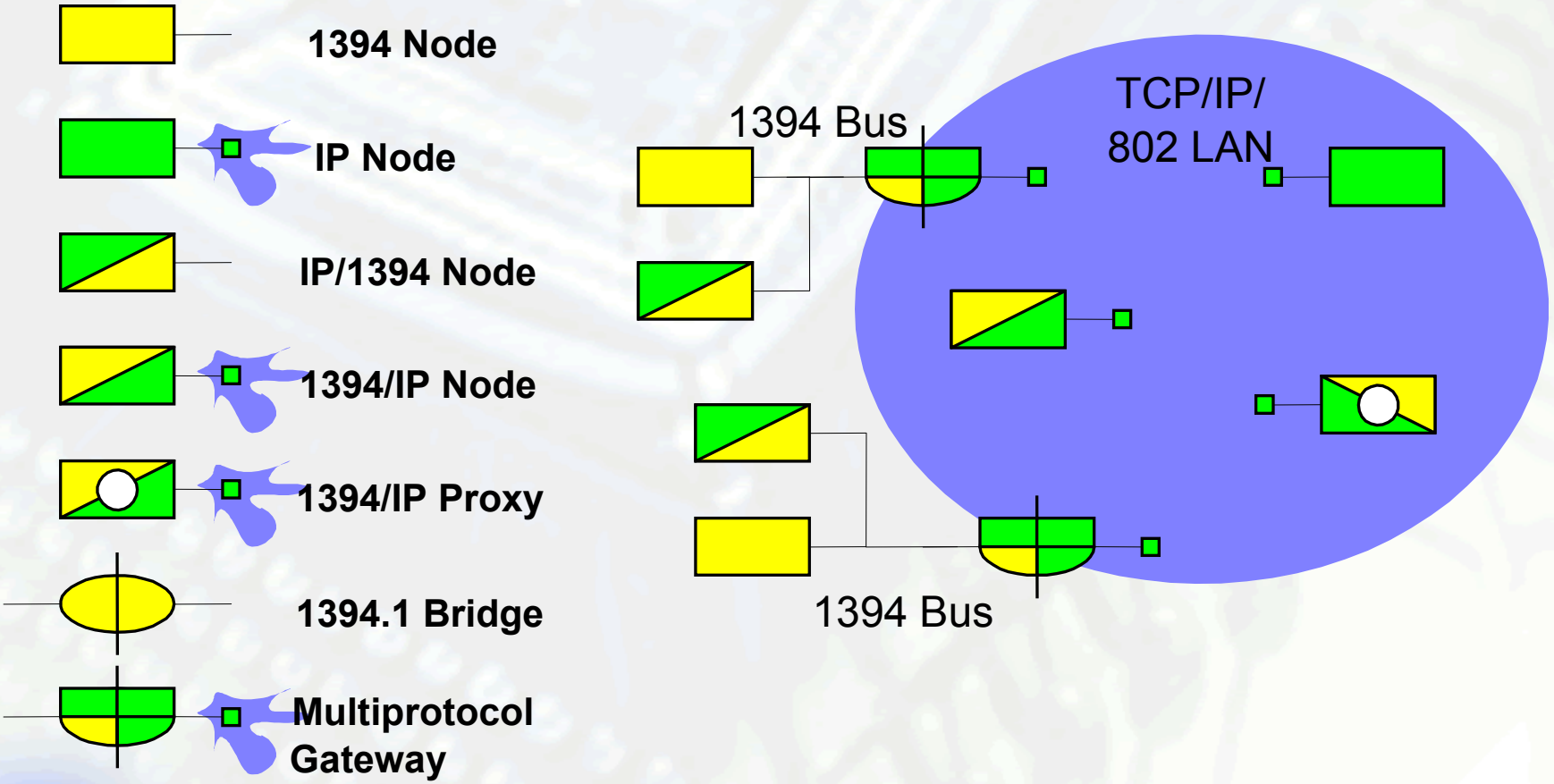


1394 over 802.11e

- Proposals under discussion in 1394 wireless working group
- May run directly over the 802.11e MAC, or using IP encapsulation
- Seamless interworking between 1394 and 802 LANs, particularly 802.11 is required
- Attach PC and other IP devices to the 1394 bus
- No brainer installation and configuration

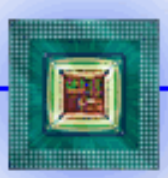


1394 and IP converged network



1394 and IP converged network

- Many different devices to be considered
- Proposed protocol makes all of them work together with minimal configuration
- Every combination of devices works together without user intervention



Summary

- 802.11e is based on over a decade of experience in design of WLAN protocols
  - approaches of all known systems were analyzed in its design, and the results applied
- 802.11e was built from the ground up for real-world wireless conditions
  - 802.11e was designed for robustness in the presence of expected hostile channel conditions
  - no credible data has ever been presented showing a WLAN protocol (even a “blank sheet of paper”) design that outperforms 802.11e *under these conditions*
- 802.11e is backwards compatible with 802.11
  - non-802.11e terminals can receive QoS-enabled application streams