The IEEE 802.1 Standards

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IEEE-SA Standards Board Operation Manual (subclause 5.9.3)
What is 802.1?

The Bridging standards
- “Traditional” Bridging
- Audio Video Bridging (AVB)
- Data Center Bridging (DCB)

The Security standards

Where to find out more
What is 802.1?

- Keeper of the LAN architecture – IEEE Std 802
  - Describes the 802 family of standards
  - Describes the LAN architecture
  - Defines some useful things, such as the LAN address format, the SNAP protocol, the “Playpen Ethertypes”, and the OID registration arcs
- The “Higher Layer Interface” working group in 802
  - Defines the Bridging and security “glue” that interconnects the LANs defined by the 802 MAC groups
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802.1 Bridging standards - 1: The core Bridging standards

- Two base standards: 802.1D:2004 (MAC Bridging) and 802.1Q:2005 (VLAN Bridging), but 802.1D will be subsumed into 802.1Q in its next revision
- Support for LAN reconfigurations in 50ms or less ("Rapid Spanning Tree")
  - Cures the historical problem of slow reconfiguration times
  - Makes Bridged Ethernet competitive as a means of offering metro services
- Support for up to 4094 VLANs over a single Spanning Tree (SST) or over multiple (up to 64) Spanning Tree instances (MST)
  - Provides options for load balancing
  - Allows choice of how VLANs map to Spanning Trees
802.1 Bridging standards – 2: Provider Bridging

- 802.1ad:2005 Provider Bridging - supports metro-area “provider” bridged LANs that can (trivially) multiplex 4094 X 4094 distinct services
- 802.1ah:2008 Provider Backbone Bridging
  - Adds a 24-bit I-SID giving ~16 million “service instance identifiers”
  - Adds a tunnelling protocol (external MAC addresses are local to the backbone)
"C" and "S" tags in 802.1Q

Customer (C-) Tag: 16 bits EtherType 12 bits VID 3 bits Priority

C-Tagged Frame: DA/SA C-Tag User Data

Service (S-) Tag: 16 bits EtherType 12 bits VID 3 bits Priority

S/C-Tagged Frame: DA/SA S-Tag C-Tag User Data
Simple provider network example

Provider Network

- C1
- C2

- 802.1ad
- 802.1D or 802.1Q

- Service Tag added & removed here

- Customer VLANs
- Service VLANs
- Customer Bridge
- Provider Bridge
Service Instance tags (I-Tags) in 802.1ah

I-Tag:

- EtherType: 16 bits
- Priority: 4 bits
- Format: 4 bits
- I-SID: 24 bits
- DA/SA: 96 bits

I-Tag:

- From encapsulated frame

I-Tagged Frame:

- DA/SA
- I-Tag
- User Data

Addresses are local to the Backbone Network
Provider Backbone Bridged LAN

Provider Backbone Bridged Network

Provider Bridged Network

Provider Bridged Network

Provider Bridged Network

802.1ah

802.1ad

Provider Bridged Network

Provider Bridged Network

802.1aj
802.1 Bridging standards – 3: Provider Bridging – Traffic Engineering (TE)

- 802.1aw:2009 Provider Backbone Bridge Traffic Engineering – supports the construction of “traffic engineered” backbone topologies, protection switching, etc. to serve the needs of large service providers.
802.1 Bridging standards – 4: Management

- 802.1ag:2007 Connectivity Fault Management and 802.1Qaw:2009 Management of Data Driven and Data Dependent Connectivity Faults
  - Fault-finding tools (continuity checks, loopback functions etc.) aimed at managing both service provider and service user networks
- 802.1ap:2008 MIB definitions for VLAN Bridges – defines the set of MIBs required in order to support SNMP-style management of all of the Bridging technologies covered by 802.1Q and 802.1D
  - Configuration and statistics gathering tools
Ongoing developments

- **P802.1aj Two-port MAC Relay**
  - Simple 2-Port Bridge – no Spanning Tree support
  - Acts as a “demarc” device between service provider and service user
  - Can be used to translate between “true” Ethernet and emulated Ethernet services

- **P802.1aq Shortest Path Bridging**
  - Intent is to provide optimal use of the available bandwidth in the network
  - Has caused a move away from distance-vector routing techniques to some variant of link state
Why Shortest Path Bridging?

- Rapid Spanning Tree confines traffic to a single Spanning Tree
  - Unused LANs, therefore wasted bandwidth
- Multiple Spanning Trees splits traffic across Spanning Trees by VLAN
  - Better utilisation of bandwidth but still can be sub-optimal paths
- Shortest Path Bridging allows connectivity trees to be created per source Bridge
  - A tree rooted at a Bridge defines the shortest path from that Bridge to any other Bridge
A Spanning Tree isn’t necessarily a Shortest Path

Bridge 1  Bridge 2  Bridge 3  Bridge 4
Bridge 5  Bridge 6

Inactive LAN segment
Active LAN segment
Shortest Path Trees

- Active LAN segment for tree rooted at Bridge 3
- Active LAN segment for tree rooted at Bridge 6
- Inactive LAN segment
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AVB: Bridging tackles home entertainment...

- Audio-visual applications in home and studio environments generate a particular set of QoS requirements
  - The need to synchronize audio/video in several adjacent rooms/areas
  - The need to prioritize AV traffic to ensure that it stays within latency/jitter bounds
  - The need to minimize packet loss
- Potentially an enormous market
  - Home AV applications
  - Studio/concert hall applications
  - Large venues e.g., theme parks
- Four standards currently under development:
  - 802.1AS – Time synchronization
  - 802.1Qat – Stream reservation protocol
  - 802.1Qav – Forwarding and queuing for time sensitive streams
  - 802.1BA – AVB Systems
A common notion of time is needed in order for distributed AV applications to synchronize
- Lip synch between audio and video streams
- Synch between different instruments in a band
- Synch between speakers in adjacent rooms playing the same music
- ...etc.

AS protocol accurately measures the delay between adjacent network nodes, and distributes a common “master” time from an accurate clock

Resilient in the face of network reconfiguration

Based on IEEE Std 1588 with extensions to meet the particular needs of LANs
P802.1Qat – Stream Reservation Protocol (SRP)

- Provides a means of reserving bandwidth for streams
- Ensures that the path from the stream originator (Talker) to the stream destinations (Listeners) is not oversubscribed
- Ensures that a Talker does not start to use network resources for a stream until those resources have been allocated to the stream
- Deals with re-assignment of resources on network reconfiguration
P802.1Qav – Forwarding and Queuing for Time Sensitive Streams

- Defines a “Credit-based shaper” de-queuing algorithm for use in Bridges
  - Stream transmission possible only if credit is not exhausted
  - Credit is accumulated in proportion to the reserved bandwidth on the Bridge port
  - Has the effect of limiting the bandwidth that can be used for streaming to the amount reserved by SRP
  - Ensures that stream traffic takes priority over all other traffic
  - Ensures that the stream latency is bounded and can be calculated for a given configuration
This defines a number of “profiles” for different applications
- Consumer – AVB in the home
- Professional/studio
- Automotive
- Industrial
Each profile selects options from the base standards (802.1Q, 802.1Qat, 802.1Qav, 802.1AS, 802.3, 802.11...etc) that are appropriate for the application
The standard may also define additional functions that don’t have a convenient home elsewhere
- E.g., detection of unacceptable configurations
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Where to find out more
And the “data centre” guys want a piece of 802.1 Bridging too...

- Data centre (“server farms”) and “backplane” use of Ethernet brings a new set of requirements for Bridging:
  - Very stringent requirements on latency and jitter
  - Active handling of congestion to avoid the impact of frame discard and retransmission
  - Result: drive to invent new Congestion Management mechanisms in LANs

- Not as big a market as AV, but the product value will be high
DCB standard developments – 1:

- **P802.1Qau, Congestion Notification:**
  - Defines a means of signalling congestion back to the source of congestion
  - Result is minimal discard rate

- **P802.1Qaz, Enhanced Transmission Selection:**
  - Defines a means of bandwidth sharing among traffic classes
DCB standard developments – 2:

- **P802.1Qbb, Priority-based flow control:**
  - Extends the existing 802.3 Pause to operate on a per-priority basis. Also involves a minor change to the 802.3 MAC control frame under P802.3bd.

- **Future project, P802.1Qbg, Edge Virtual Bridging:**
  - Extends the Bridging standards to support virtual machine developments within desktop and server systems.
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The 802.1 Security standards: 1

- **802.1X:2004 Port based Network Access Control:**
  - Defines a “Controlled Port” accessible only after EAP-based authentication, and an “Uncontrolled Port” accessible at any time
  - 2009 revision adds “key agreement” protocol

- **802.1AE:2006 MAC Security:**
  - Defines a means of securing data on an individual LAN segment
  - Integrated with the key agreement and controlled/uncontrolled Port functions in 802.1X
Security architecture

Legend:
- (L) – Port
- (C) – Controlled Port
- (U) – Uncontrolled Port
- (M) – Common Port
- LMI communication

Authentication exchange using EAPOL
Peer discovery and key agreement

Authorization data provided as Radius attributes
Authentication exchange using EAP in Radius

Secured access controlled communication
Cryptographically secured communication

Legend:
- Port
- Controlled Port
- Uncontrolled Port
- Common Port
- LMI communication
The 802.1 Security standards: 2

- P802.1AR Secure Device Identity:
  - Defines unique per-device identifiers
  - Allows standard mechanisms to authenticate a device’s identity
  - Facilitates secure device provisioning
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Where to find out more
More information is available on IEEE 802.1 standards and activities here...

http://www.ieee802.org/1/

Free PDF copies of IEEE 802 standards available from...

http://standards.ieee.org/getieee802/index.html

...but only 6 months after publication
Summary of 802.1 Standards and Projects (1) - Bridging

- Base Bridging standards (published):
  - IEEE Std 802.1D:2004, MAC Bridges
  - IEEE Std 802.1Q:2005, Virtual Bridged Local Area Networks

- Amendments to IEEE Std 802.1Q:2005 (published):
  - IEEE Std 802.1ad:2005 – Provider Bridging
  - IEEE Std 802.1ag:2007, Connectivity Fault Management
  - IEEE 802.1ak:2007, Multiple Registration Protocol
  - IEEE 802.1Q:2005 Cor 1:2008 (bug fix for 802.1ak)
  - IEEE 802.1ah:2008, Backbone Provider Bridges
  - IEEE 802.1ap:2008, MIB definitions for VLAN Bridges
Summary of 802.1 Standards and Projects (2) - Bridging

- Amendments to IEEE Std 802.1Q:2005 (active projects, with probable completion date):
  - P802.1aj, Two-port MAC Relay (Submitted for Standards Board approval in December 2009)
  - P802.1Qav, Forwarding & Queuing for Time Sensitive Streams. (Submitted for Standards Board approval in December 2009)
  - P802.1aq, Shortest Path Bridging (Working Group ballot; Completion Dec 2010)
  - P802.1Qat, Stream Reservation Protocol. (Starts Sponsor Ballot in December; completion July 2010)
  - P802.1Qau, Congestion Notification. (Sponsor ballot; completion July 2010)
  - P802.1Qaz, Enhanced Transmission Selection. (Task Group ballot; completion 2011)
  - P802.1Qbb, Per-priority flow control. (Task Group ballot; completion 2011)
  - P802.1Qbc – Remote Customer Service Interface. (Task Group ballot; completion 2011)
  - P802.1Qbe – Multiple I-SID Registration Protocol. (Task Group ballot; completion 2011)
  - P802.1Qbf – PBB-TE infrastructure protection. (Task Group ballot; completion 2011)
Summary of 802.1 Standards and Projects (3) - Security

Published standards:
- IEEE Std 802.1X:2004, Port-based Network Access Control
- IEEE Std 802.1AE:2006, MAC Security

Active projects:
- P802.1X, Port-based Network Access Control. (Revision project; submitted for Standards Board approval December 2009)
- P802.1AR, Secure Device Identity. (Submitted for Standards Board approval December 2009)
Summary of 802.1 Standards and Projects (4) – The rest...

Published standards:
- IEEE Std 802:2001, Overview and Architecture
- IEEE Std 802a:2003, Ethertypes for Prototype and Vendor-Specific Protocol Development
- IEEE Std 802b:2004 Registration of Object Identifiers
- IEEE Std 802.1H:1995, MAC Bridging of Ethernet (currently under revision)

Active projects:
- P802.1AS, Time Synchronization (Expected to start Sponsor balloting in December 2009)
- P802, Overview and Architecture (Expected completion December 2011)
- P802.1AC, MAC Service Definition (Expected completion December 2010)
- P802.1H:1995, MAC Bridging of Ethernet (Revision project. Expected completion December 2010)