Babel for IEEE 802.11 (Wi-Fi) Mesh

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Disclaimers

- I was the Chair of the IEEE 802.11s Task Group for approximately the first half of its existence. But that was quite a while ago. There may be errors in this presentation.
- IEEE 802.11 is a complex standard when you consider all the options. Latest full version (802.11-2020) has 4,377 pages. Many details are omitted in this presentation. (You can get a copy through https://standards.ieee.org/products-services/ieee-get-program.html)
- The opinions, comments, endorsements, and other such information provided here are not those of the IEEE Inc. or IEEE 802 or IEEE 802.11, they are solely the opinion of their author.

Contents

Motivation

- Babel routing does well at handling links, such as radio links, with unstable link metrics.
- IEEE 802.11 (Wi-Fi) mesh (802.11s) is composed of such radio links.
- Therefore, using Babel routing in Wi-Fi mesh seems reasonable.

802.11 (Wi-Fi) Miscellaneous

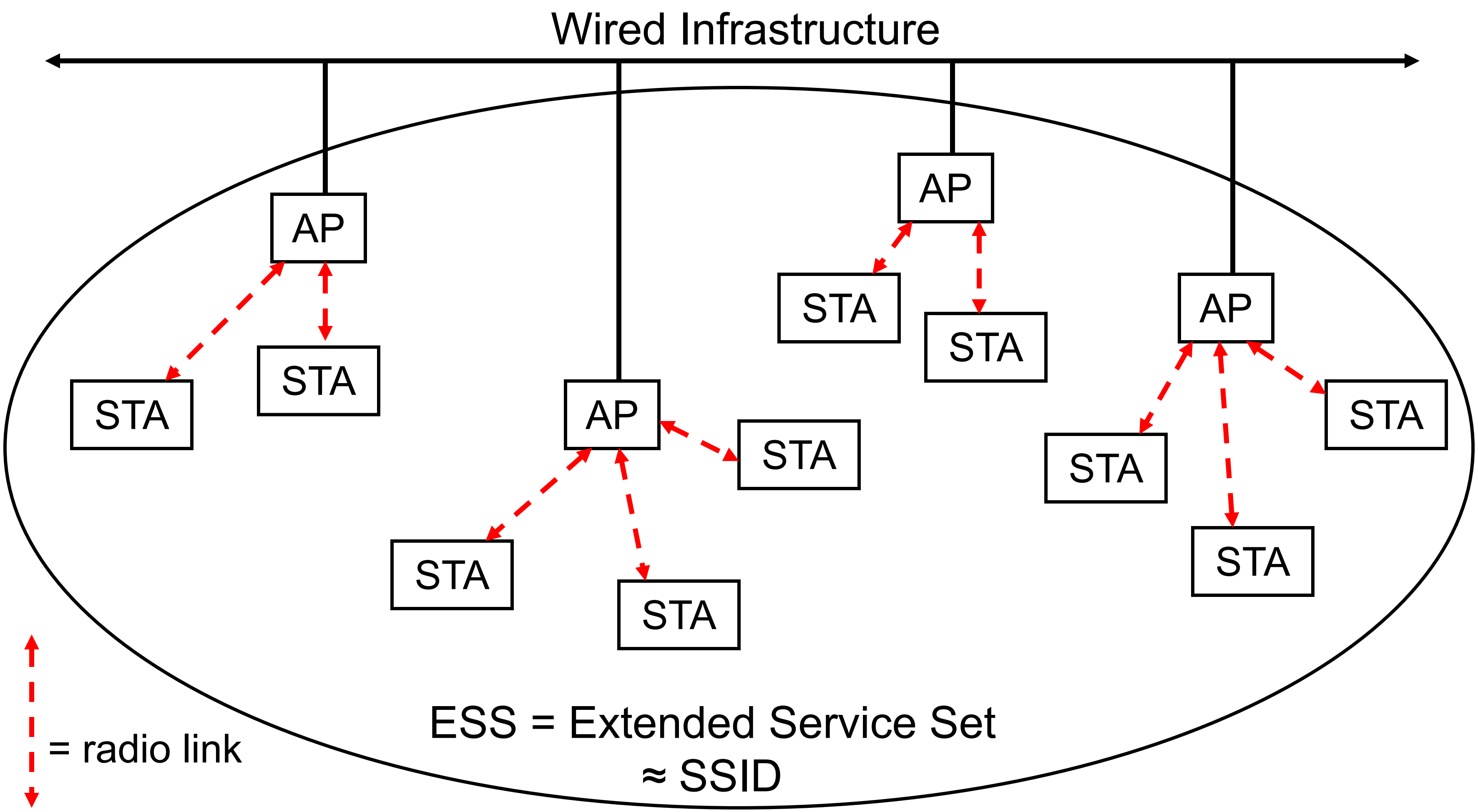
- 802.11 (Wi-Fi) has a lot going for it:
  - Negotiates and adjusts data rates, beam forming, channel switching, national spectra, licensing regimes, etc.
  - Has a variety of aggregation / fragmentation features.
  - Has link level (one-hop) acknowledgement / retransmission (can be defeated with the No Acknowledgement header bit).
  - Radio communication being assumed insecure, encryption and authentication normally implemented in hardware / firmware so there is almost no cost or slowdown in using it.
  - Billions of 802.11 chip sets ship annually.
- Range goal is 100 meters. (It's 10 meters for Bluetooth.)
- 802.11 uses a unified complex header with many options/flags.

802.11 Mesh Background

- Original Motivation was to provide wireless backhaul for Wi-Fi Access Points (APs) and was limited to meshing between APs. Later generalized.
- Chartered May 2004. First 802.11 WG Letter Ballot January 2007. Final 802.11 approval July 2011.
- Final 802.11s Amendment to 802.11 had 344 pages. Has been rolled into the base standard.
- For a list of implementations, see https://en.wikipedia.org/wiki/IEEE_802.11s .

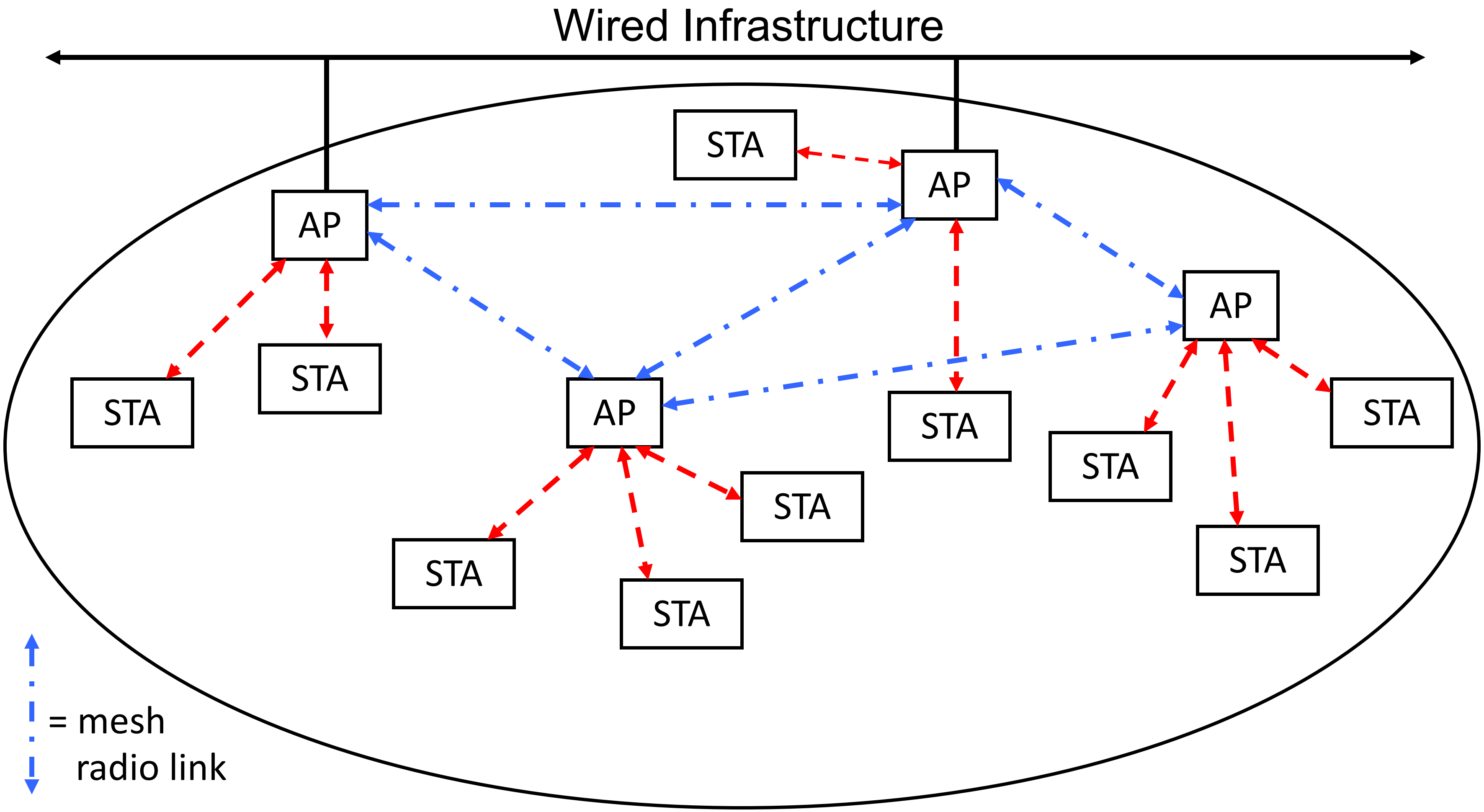
802.11 Mesh Background

Classic ESS



802.11 Mesh Background

Initial 802.11 mesh concept



Existing 802.11 Mesh

- Links between mesh stations are peer-to-peer.
- Mesh stations have a mesh profile, which must be the same for two mesh station to peer, consisting of the following:
  1. Mesh ID
  2. Path selection protocol identifier
  3. Path selection metric identifier
  4. Congestion control mode identifier
  5. Synchronization method identifier
  6. Authentication protocol identifier

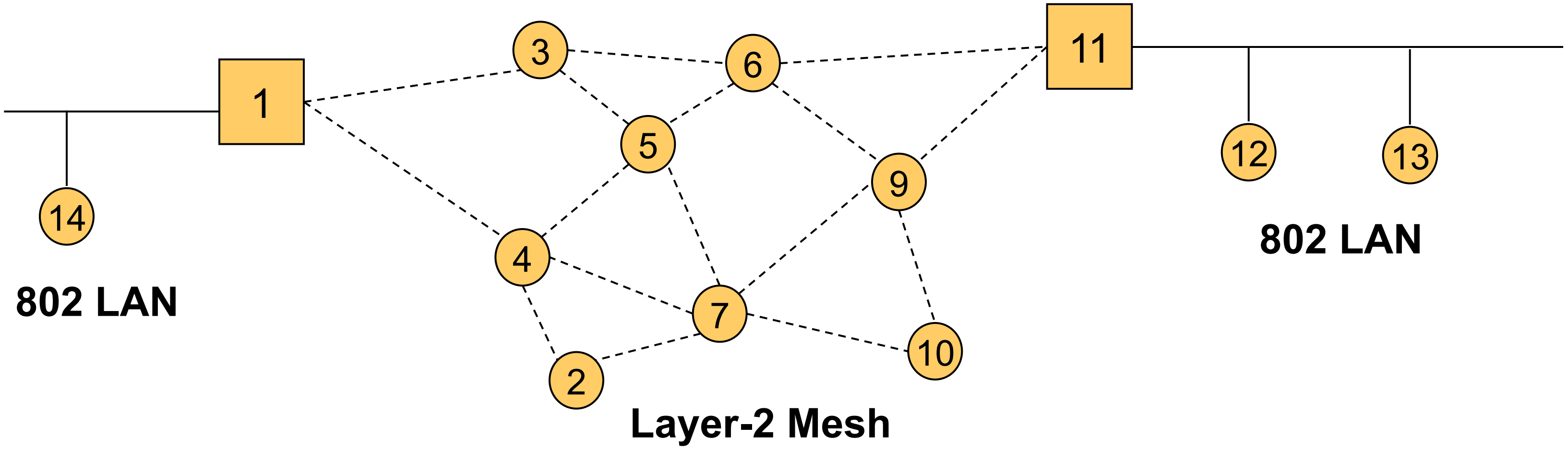
Existing 802.11 Mesh

- Mesh stations discover each other through Beacon transmissions or Probe Request / Probe Response messages.
  - These contain a Mesh Configuration element which includes a 1 octet Path Selection Protocol ID field and 1 octet Path Selection Metric ID field. 0xFF escapes to vendor (identified by OUI) specified.
  - The SSID is not used (set to the wildcard value) and there is a 0-32 octet Mesh ID element.

Existing 802.11 Mesh

- An 802.11 Mesh appears, from an external point of view, to be a single multi-access link. It can connect to networks that are not 802.11 meshes via mesh stations that are mesh gates and portals.
  - Mesh stations can also be Access Points (APs).
  - Any two or all of the AP, mesh gate, and Portal functions could by co-located in one mesh station device.

Existing 802.11 Mesh



Existing 802.11 Mesh

- 802.11 Mesh routing is based on MAC addresses.
  - The most general unicast 802.11 mesh data frame has six MAC addresses.
    - Transmitter and Receiver
    - Mesh source and mesh destination
    - Original source and final destination (both outside the mesh)
- Mesh data frames have a TTL and 4 octet mesh sequence number. Duplicates with the same mesh source and sequence number are dropped.

Existing 802.11 Mesh

- The default path selection protocol is HWMP (Hybrid Wireless Mesh Protocol). It consists of the following:
  - An on-demand mode always available based on AODV (Ad-hoc On-Demand Distance Vector, RFC 3561); and
  - Pro-active tree building mode based on configuring a Mesh station as a root.

Existing 802.11 Mesh

- The default link metric is the "airtime" metric:

$$cost = \left[O + \frac{B_t}{r}\right]\frac{1}{1 - e_f}$$

  - O = Channel access overhead, which includes frame headers, training sequences, access protocol frames, etc.
  - B_t = Number of data bits in test frame (8192 recommended).
  - r is the data rate in Mb/s.
  - e_f is the frame error rate for a frame of size B_t.

Existing 802.11 Mesh Miscellaneous Stuff

- Mesh stations are required to support certain 802.11 QoS features.
- Mesh has its own power save tweaks. Each peering is, at any particular time, either active, light sleep, or deep sleep mode.
- Has a beacon collision avoidance feature, to avoid collisions with hidden nodes, and a congestion avoidance feature.
- Handles channel switching.
- Emergency Services support.

Babel for 802.11 Mesh

- What the Babel WG could do:
  1. Specify how to use Babel routing as an 802.11 Mesh Path Selection Protocol.
     - Would probably need a new Babel Address Encoding for MAC addresses.
  2. Possibly specify an 802.11 Mesh Link Metric, for example based on ETX (RFC 8966, Appendix A.2.2).

Process Points

- 802.11 mesh is clearly designed for additional path selection protocols and path selection metrics to be specified, including by “vendors”.
- Nevertheless, the IESG/IETF is going to want an explicit liaison from the IEEE 802.11 Working Group allowing / approving before we do any significant amount of work on this.
  - Such approval might be useful if we need identifiers other than IDs for a path selection protocol and path selection metric.
- Might need Charter update?

END

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