

BABEL for IEEE 802.11 (Wi-Fi) Mesh

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About BABEL

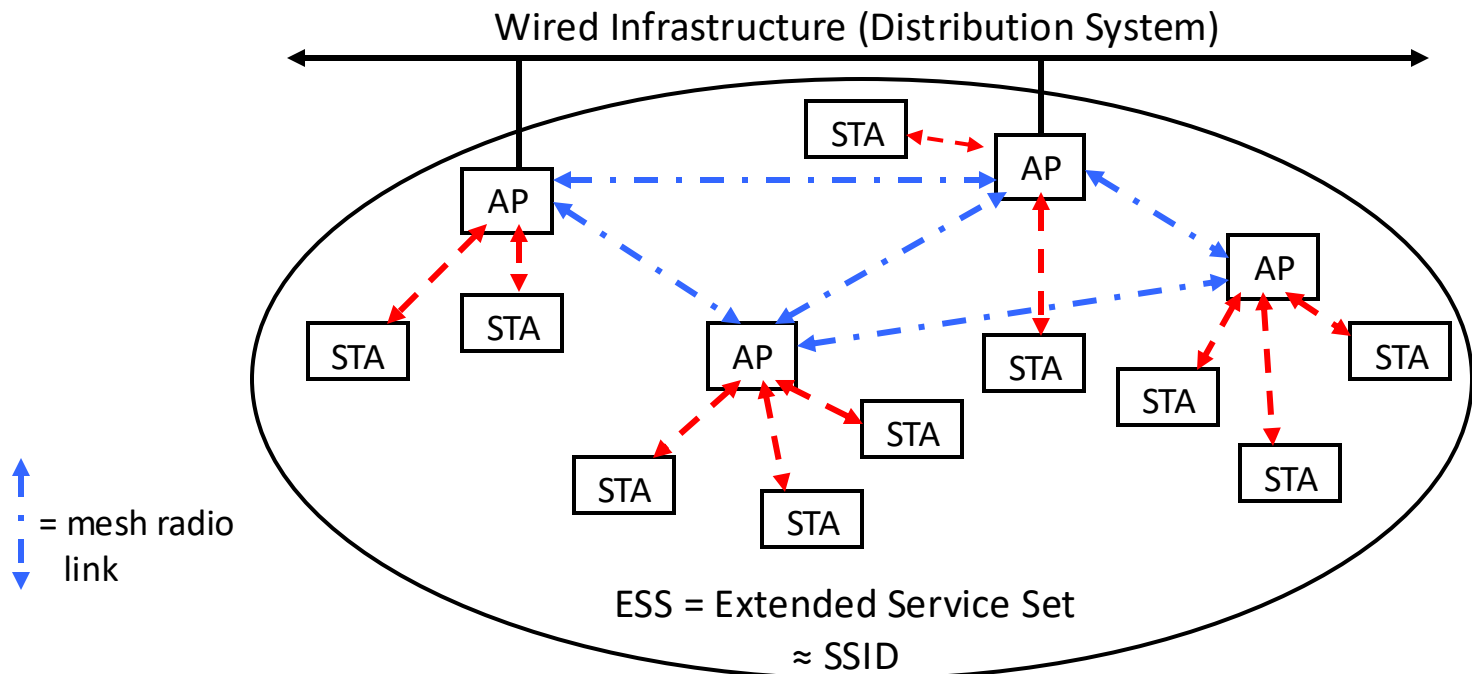
- Babel is based on the distance-vector algorithm (also known as distributed Bellman-Ford) augmented with mechanisms for loop avoidance and starvation avoidance. Babel has been described as “RIP on speed” since it is based on the same principles but has refinements that make it react much faster to topology changes.
- In practice, Babel had proven to be particularly effective in networks consisting of a mixture of high- and low-quality links or links with time varying quality, such as wireless or hybrid wireless/wired networks.

About BABEL (continued)

- Babel is standardized in **RFC 8966**:
- It did well in the European Battlemesh contests. See <https://battlemesh.org/BattleMeshV8> (Results tabs).
- Multiple opensource implementations:
 - BIRD <https://gitlab.nic.cz/labs/bird/tree/master/proto/babel>
 - FRR <https://docs.frrouting.org/en/latest/babeld.html>
- See [https://en.wikipedia.org/wiki/Babel_\(protocol\)](https://en.wikipedia.org/wiki/Babel_(protocol))
- Babel in depth:
 - <https://www.irif.fr/~jch/software/babel/babel-20150804.pdf>
(References earlier RFC 6126 which has been obsoleted by RFC 8966)

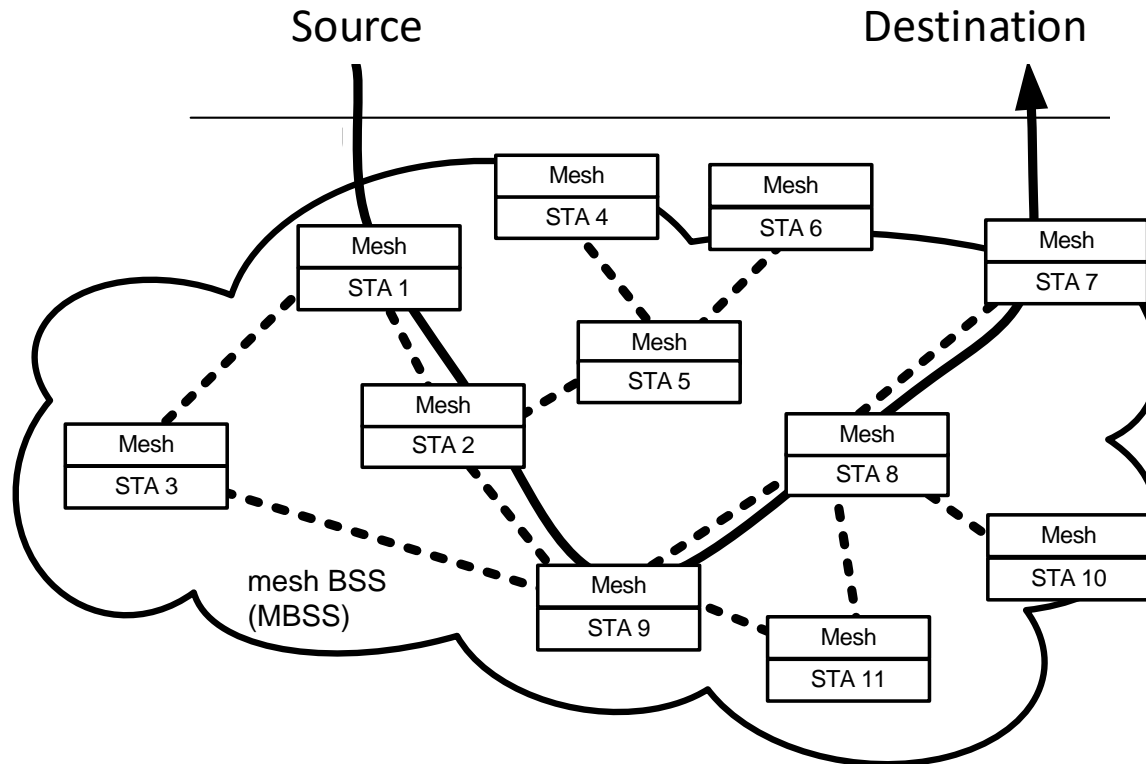
About IEEE 802.11 Mesh

- 802.11 Mesh (802.11s) was initially targeted just at “wireless backhaul” to allow multiple hops through Access Points.



About IEEE 802.11 Mesh (cont.)

- Mesh was generalized and, while still useful for wireless backhaul, is visualized more like this, appearing to be a link:

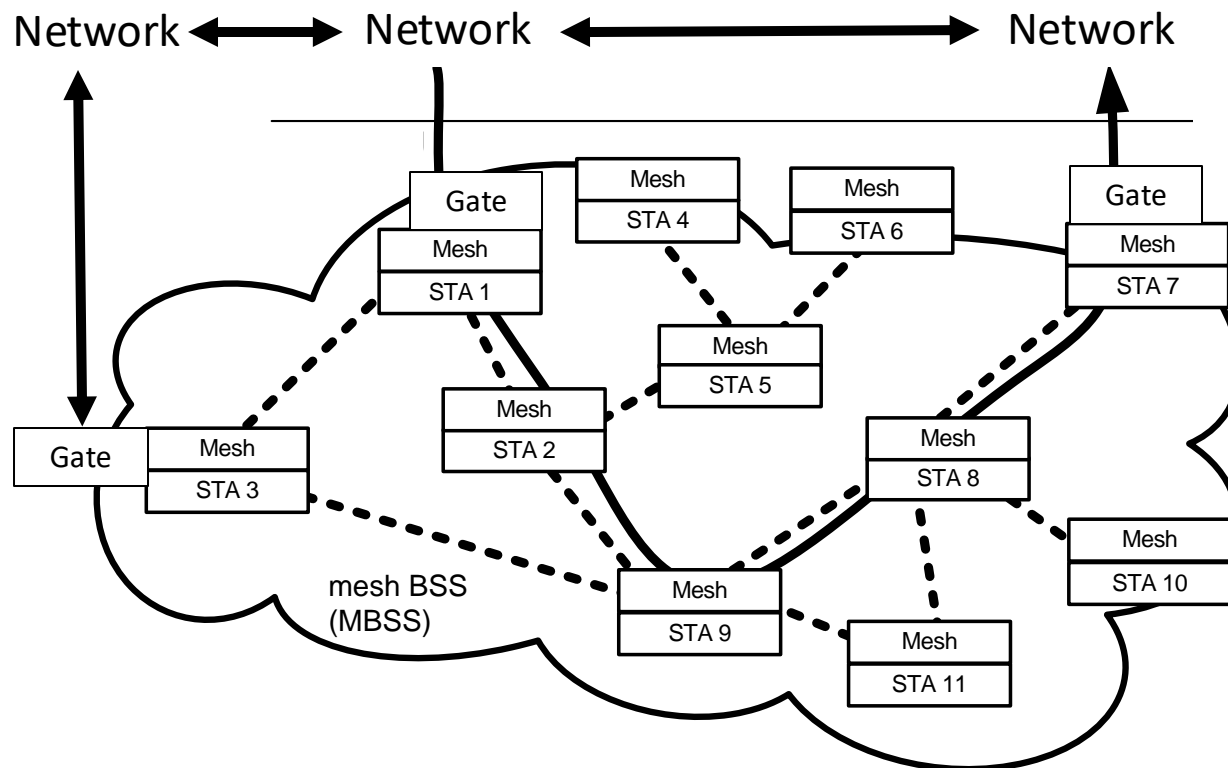


About IEEE 802.11 Mesh (cont.)

- In an 802.11 mesh, all stations send mesh beacon frames periodically that include Mesh ID, Path Selection Protocol & Path Metric, etc. Matching mesh stations peer with each other and negotiate pairwise keying. Each distributes its group key to its peers.
- The entire mesh appears from outside to be a layer 2 link which may be multi-access.
- Frames sent over a radio link inside an 802.11 mesh have up to 6 MAC addresses.
 - SA = Source Address, DA = Destination Address
 - MSA = Mesh Source Address (where frame enters mesh or originated inside mesh)
 - MDA = Mesh Destination Address (where frame exits mesh or terminated inside mesh)
 - TA = Radio Transmitter Address, RA = Radio Receiver Address

About IEEE 802.11 Mesh (cont.)

- How are loops through networks outside the mesh stopped?
This is all layer 2 so it just uses spanning tree if needed.



About IEEE 802.11 Mesh (cont.)

- An 802.11s mesh depends on the Path Selection Protocol and Link Metric for that mesh to determine how to forward frames.
- It was realized, when 802.11s was developed, that different path selection protocols would be suitable for different mesh conditions and/or mesh station types. Thus 802.11 mesh was designed to be extensible by specifying additional Path Selection Protocols and Link Metrics, including those developed outside of 802.
- The default path selection protocol and the only one specified in the 802.11 Standard is HWMP (Hybrid Wireless Mesh Protocol) based on AODV with tree-based additions. (Early in the standardization effort for 802.11s it also had a “Radio Aware OLSR” based alternate Path Selection Protocol but this was removed.)

About IEEE 802.11 Mesh (cont.)

- (Like most major features added to 802.11, 802.11 mesh also has its own power save, congestion management, etc. features.)
- 802.11s no longer exists as a separate document but has been merged with the main IEEE 802.11 Standard whose most recent version is 2020. “802.11 Std 2020” is available through the Get 802 Program.
 - See <https://ieeexplore.ieee.org/browse/standards/get-program/page>

Deployment of Standard 802.11 Mesh

- There are implementations/uses of 802.11s mesh and HWMP.
 - See https://en.wikipedia.org/wiki/IEEE_802.11s
 - Has been implemented in Linux and BSD Unix
 - Early version in One Laptop Per Child
- Wi-Fi mesh products are widely available but are not usually based on the 802.11 Standard for Wi-Fi Mesh.
- In my personal opinion, the 802.11s has not been very successful for two reasons:
 - To get good performance with mesh, you need multiple radios per node. This has only been standardized recently in 802.11be.
 - Some meshes may work better with a different routing protocol.

BABEL for 802.11 Mesh

What could BABEL for 802.11 encompass?

- Primarily, an IETF RFC specifying how to use the fundamental BABEL routing method inside IEEE 802.11 Mesh as a Path Selection Protocol.
- Secondarily:
 - An IETF RFC (or part of an RFC) specifying how to use BABEL Link Metrics inside IEEE 802.11 Mesh.
Example metric:
 - <https://datatracker.ietf.org/doc/html/rfc9616>
- Tertiarily (more like 802.11 for BABEL):
 - Specify how to use the 802.11 Air Time Link Metric in BABEL.

BABEL for 802.11 Mesh

- An 802.11s Path Selection Protocol based on BABEL would be simpler than the existing RFC 8966 network layer specification.
 - There would be no need to carry prefixes, just sets of MAC addresses.
 - There would be no need to distinguish between router-id and address – the MAC address can serve as both.
 - Would not need BABEL Security (RFC 8967 and RFC 8968) since 802.11 has its own security.

Thus, it would be a simpler protocol.

- BABEL is very flexible on the link metric used as long as it is monotonic and thus should work well with the 802.11 Air Time metric.

We Have Explicit Permission from IEEE 802.11 to Do This

- Presentation to IEEE 802.11 May 2023 Meeting
 - <https://mentor.ieee.org/802.11/dcn/23/11-23-0769-00-0000-babel-for-802-11-mesh.pptx>
- Liaison to the IETF from IEEE 802.11
 - <https://www.ietf.org/lib/dt/documents/LIAISON/liaison-2023-06-07-ieee-802-11-babel-liaison-to-ietf-babel-wg-on-alternative-path-selection-protocol-attachment-1.pdf>

“... While the IEEE 802.11 WG has no view on whether such an activity is justified or not, the IEEE 802.11 WG has no objection to such work being undertaken in the IETF. Such work is possible because the IEEE 802.11 standard was designed to enable the development of a variety of mesh path selection protocols and/or link metrics to extend the range of conditions for which an IEEE 802.11 mesh is suitable. ...”

Next Step

- Some person or persons should write a draft !

END

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