



Wi-Fi EasyMesh®

Technologie, Herkunft,
Weiterentwicklung





Philipp Ebbecke

2022: Product Manager Wi-Fi,
Genexis

2011-2022: Quality Manager
Wi-Fi, LANCOM Systems



(Easy)Mesh Netzwerk



Zwei oder mehr WLAN-Geräte bilden ein nahtloses Netzwerk mit:

- WLAN oder Ethernet als Backhaul
- zentral verwalteten WLAN-Profilen
- gleichen SSIDs auf allen Geräten
- einfacher Einrichtung und Management
- verbesserter Abdeckung größerer Gebäude und Flächen
- erweiterten Diagnosedaten





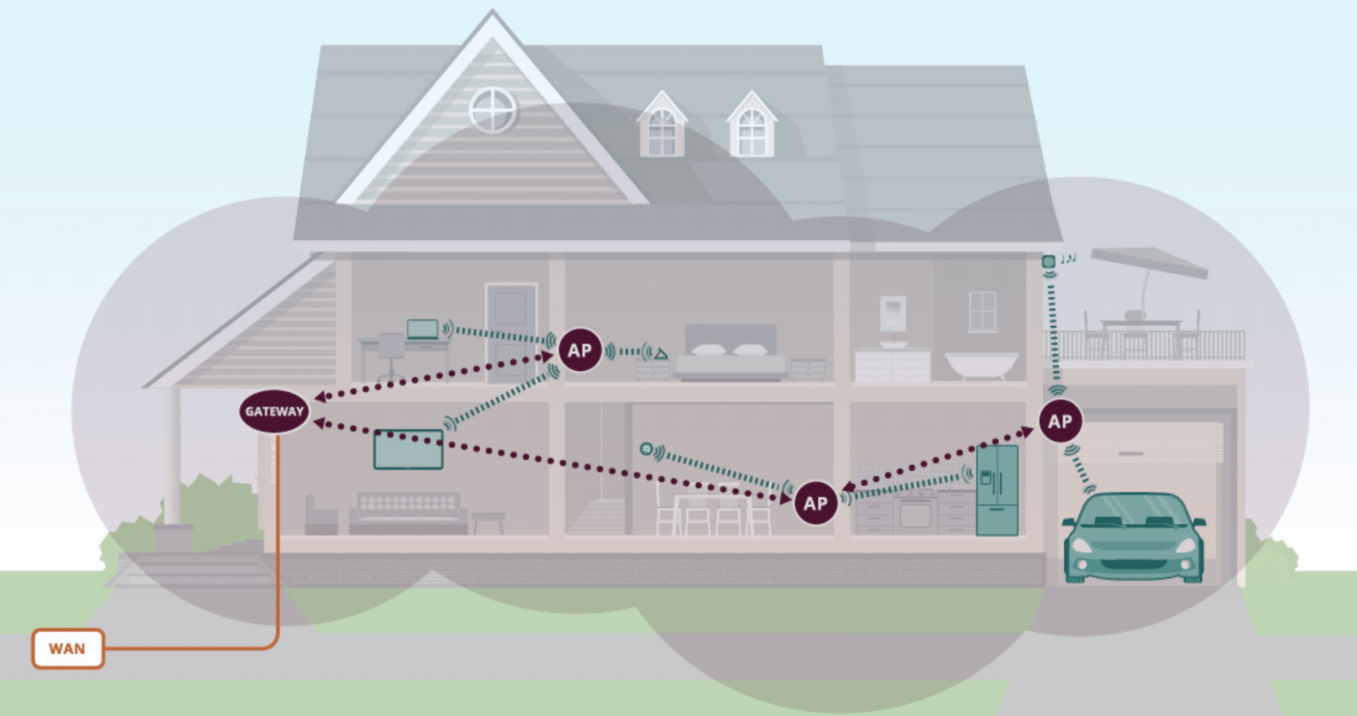
EasyMesh vs. Enterprise Netzwerk

	EasyMesh	Enterprise
Controller	Offiziell nur 1 Controller	1 Controller + Backup-Controller
Lokal oder Cloud basiert?	Eher Lokal	Lokal oder Cloud
Multi-Vendor-fähig?	✓	✗
Netzwerkprofile	✓	✓
Radioprofile	✓	✓
Zertifikate	✗	✓
Getrennte Netze (z.B. Gäste)	✓	✓
Client Steering	✓	✓
Fast Roaming	✓	✓
Access Management (z.B. Zeitsteuerung, MAC-Blocking)	✓	✓
Data Elements (TR-181)	✓	?
Firmware Management	✗	✓



Einführung EasyMesh

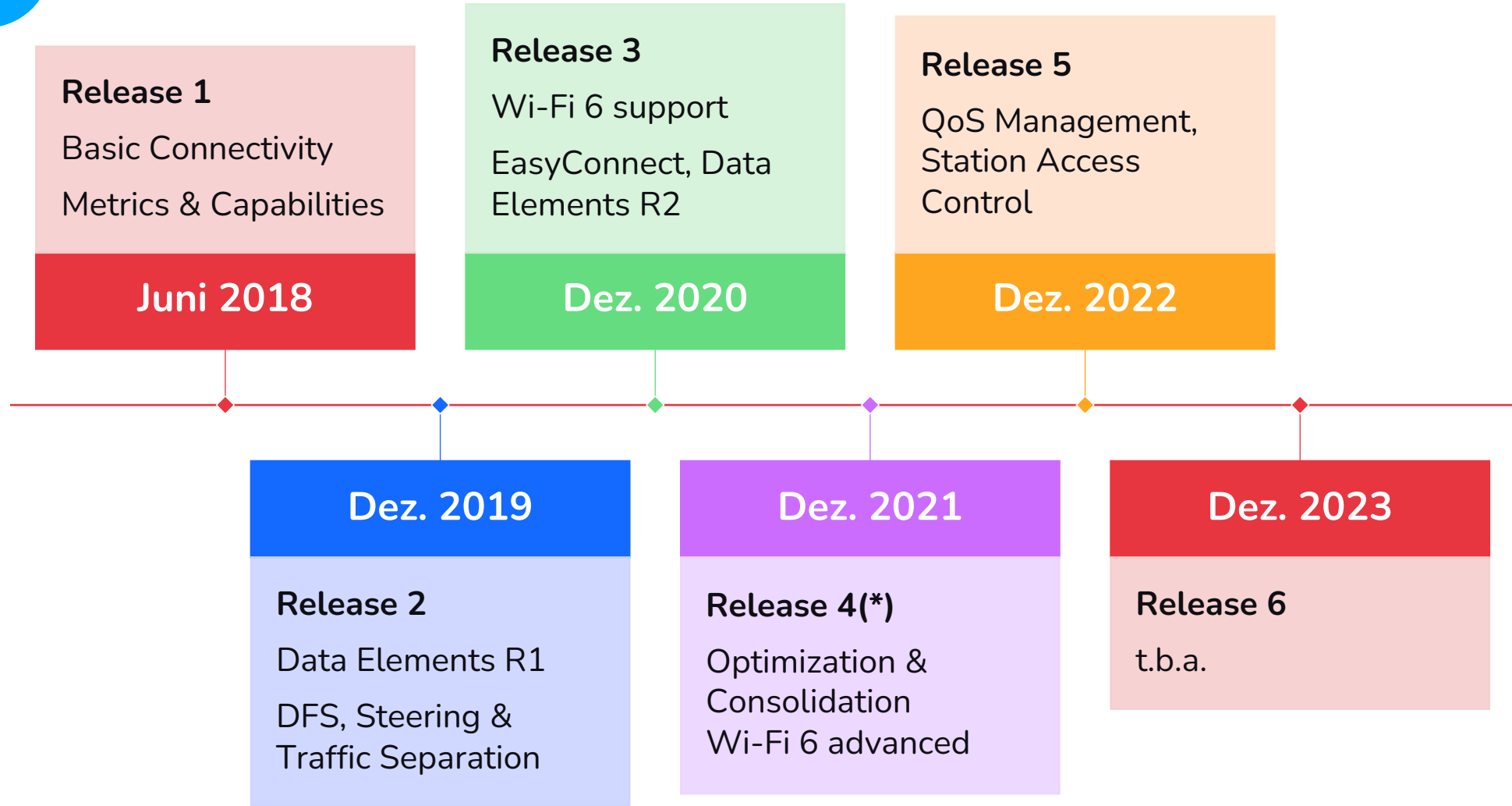
Wi-Fi CERTIFIED EasyMesh™:
Smart, extended coverage home Wi-Fi®



- Mesh-Interoperabilität ursprünglich seitens Chiphersteller entwickelt
- Wi-Fi Alliance (WFA) integrierte den vorliegenden Testplan als EasyMesh (R1) in 2018
- Zertifizierte Geräte: >450
 - >100 zertifizierte Geräte pro Jahr seit 2020
 - Top vendors: Huawei (145), ZTE (68), Fiberhome (34)



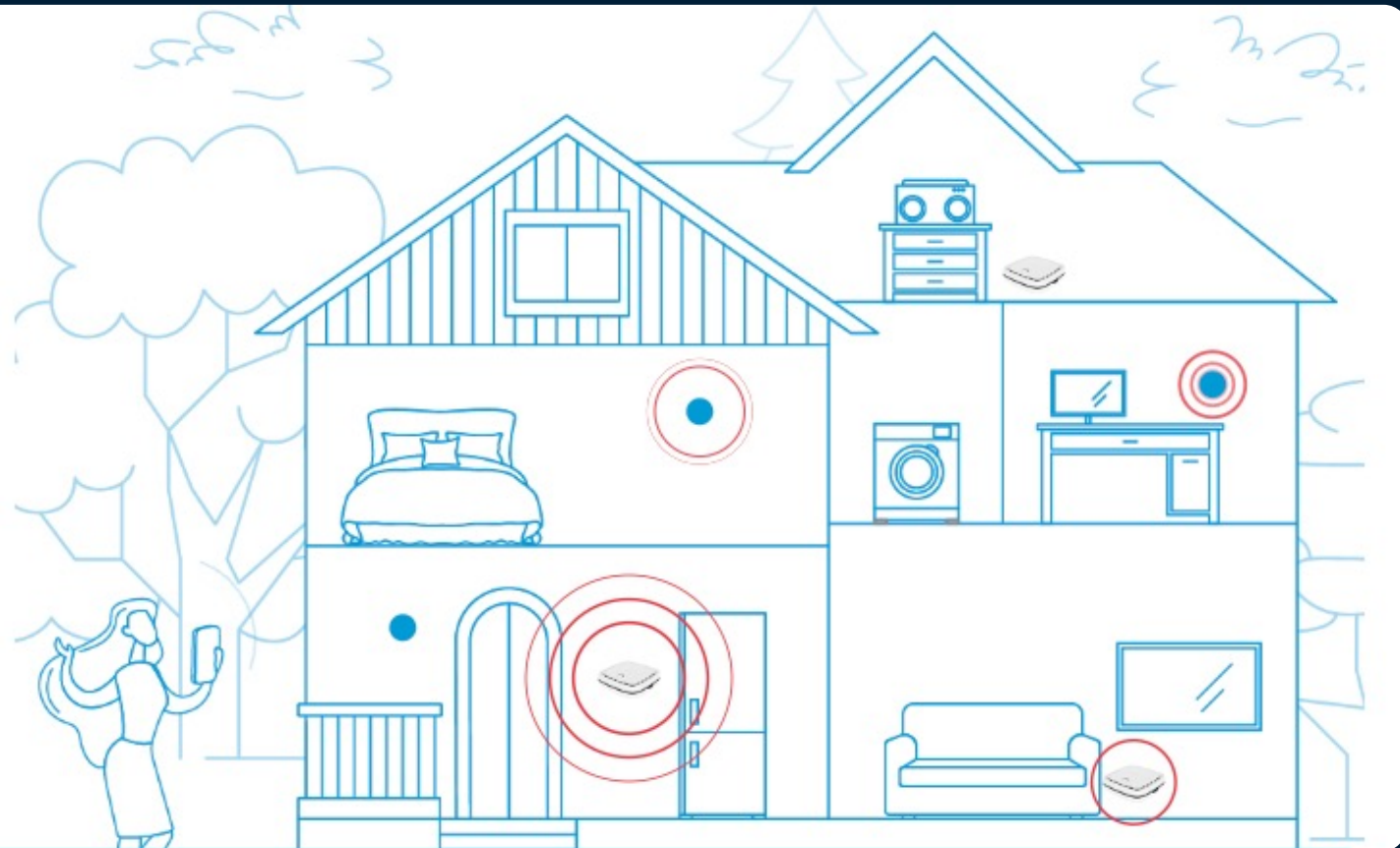
Zeitverlauf



(*) Seit Dezember 2022 für Zertifizierung verpflichtend



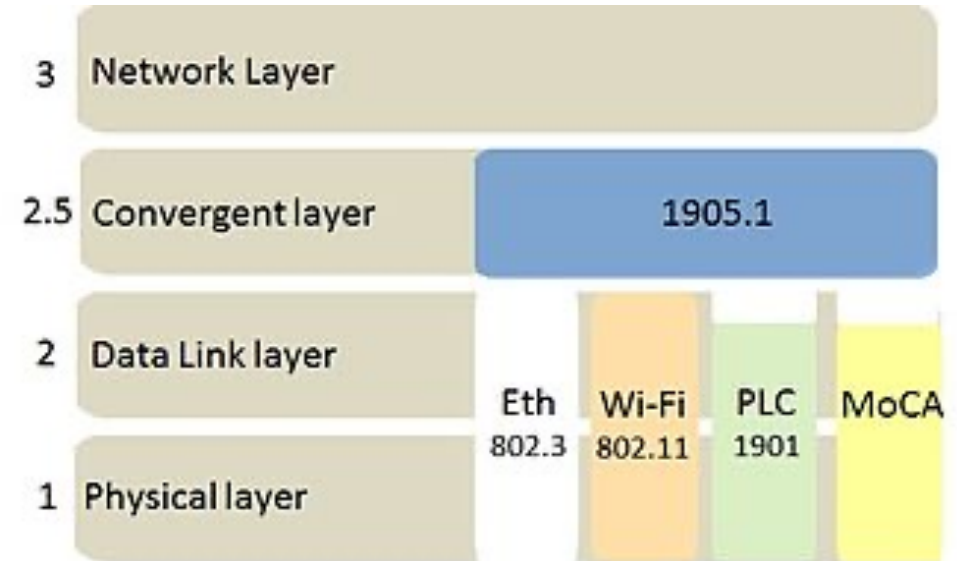
EasyMesh Technologie





EasyMesh unter der Haube

- Erkennung, Konfiguration und Management erfolgt via IEEE 1905.1/.1a
- AP „Auto-Konfiguration“ nutzt “Wi-Fi Simple Configuration“ (WPS)
- Onboarding von Geräten via WPS (R1+) und/oder Easy Connect (R3+)
- Remote Management via TR-181 inkl. Data Elements





EasyMesh unter der Haube

IEEE 1905.1/.1a

Packet Capture

Austausch

- „Autoconfig“ Suche
- Topologie
- Link Qualität
- Kanalwahl inkl. Sendeleistung
- Radio Metriken



EasyMesh unter der Haube: Ankündigung

No.	Time	Source	Destination	Protocol	Length	Info
1	0.000000	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	Topology discovery
2	0.002006	EasyMesh:Controller	IEEE-1905.1-Control	ieee1905	60	Topology discovery
3	0.003053	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	Topology discovery


```
> Frame 1: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Agent (46:d4:37:97:a8:40), Dst: IEEE-1905.1-Control (01:80:c2:00:00:13)
✓ IEEE 1905.1a
  Message version: 0
  Message reserved: 0
  Message type: Topology discovery (0x0000)
  Message id: 0x9b8d
  Fragment id: 0x00
  > Flags: 0x80 Last fragment
  ✓ 1905 AL MAC address type
    TLV type: 1905 AL MAC address type (0x01)
    > TLV length: 6
    1905 AL MAC address type: EasyMesh:Agent (46:d4:37:97:a8:40)
  ✓ MAC address type
    TLV type: MAC address type (0x02)
    > TLV length: 6
    MAC address type: EasyMesh:Agent (44:d4:37:97:a8:40)
  ✓ End of message
```



EasyMesh unter der Haube: Autoconfig Suche

No.	Time	Source	Destination	Protocol	Length	Info
3	5.420353	EasyMesh:Agent	IEEE-1905.1-Control	IEEE1905	60	Topology discovery
4	5.420438	EasyMesh:Agent	IEEE-1905.1-Control	IEEE1905	60	AP autoconfiguration search
5	5.421599	EasyMesh:Agent	IEEE-1905.1-Control	IEEE1905	60	AP autoconfiguration search
6	5.422462	EasyMesh:Controller	EasyMesh:Agent	IEEE1905	60	AP autoconfiguration response


```
> Frame 4: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Agent (44:d4:37:97:a8:40), Dst: IEEE-1905.1-Control (01:80:c2:00:00:13)
  IEEE 1905.1a
    Message version: 0
    Message reserved: 0
    Message type: AP autoconfiguration search (0x0007)
    Message id: 0x9b94
    Fragment id: 0x00
    > Flags: 0xc0, Last fragment, Relay indicator
    < 1905 AL MAC address type
      TLV type: 1905 AL MAC address type (0x01)
      > TLV length: 6
      1905 AL MAC address type: EasyMesh:Agent (46:d4:37:97:a8:40)
    < SearchedRole
      TLV type: SearchedRole (0x0d)
      > TLV length: 1
      Searched role: 0x00, Registrar
    < AutoconfigFreqBand
      TLV type: AutoconfigFreqBand (0x0e)
      > TLV length: 1
      Auto config frequency band: 0x01, 802.11 5 GHz
    < Supported service information
      TLV type: Supported service information (0x80)
      > TLV length: 2
      Supported service count: 1
      > Supported service list
    < Searched service information
      TLV type: Searched service information (0x81)
      > TLV length: 2
      Searched service count: 1
      > Searched service list
    < Multi AP Profile
      TLV type: Multi AP Profile (0xb3)
      > TLV length: 1
      Multi-AP Profile: Multi-AP Profile 2 (2)
    > End of message
```



EasyMesh unter der Haube: Autoconfig Suche - pro Band(!)

No.	Time	Source	Destination	Protocol	Length	Info
3	0.003053	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	Topology discovery
4	5.420438	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	AP autoconfiguration search
5	5.421599	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	AP autoconfiguration search
6	5.422462	EasyMesh:Controller	EasyMesh:Agent	ieee1905	60	AP autoconfiguration response


```
> Frame 5: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Agent (44:d4:37:97:a8:40), Dst: IEEE-1905.1-Control (01:80:c2:00:00:13)
v IEEE 1905.1a
  Message version: 0
  Message reserved: 0
  Message type: AP autoconfiguration search (0x0007)
  Message id: 0x9b95
  Fragment id: 0x00
  > Flags: 0xc0, Last fragment, Relay indicator
  > 1905 AL MAC address type
  > SearchedRole
v AutoconfigFreqBand
  TLV type: AutoconfigFreqBand (0x0e)
  > TLV length: 1
  Auto config frequency band: 0x00, 802.11 2.4 GHz
  > Supported service information
  > Searched service information
  > Multi AP Profile
  > End of message
```




EasyMesh unter der Haube: Autoconfig Suche - Antwort

No.	Time	Source	Destination	Protocol	Length	Info
4	5.420438	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	AP autoconfiguration search
5	5.421599	EasyMesh:Agent	IEEE-1905.1-Control	ieee1905	60	AP autoconfiguration search
6	5.422462	EasyMesh:Controller	EasyMesh:Agent	ieee1905	60	AP autoconfiguration response
7	5.423677	EasyMesh:Controller	EasyMesh:Agent	ieee1905	60	AP autoconfiguration response


```
> Frame 6: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Controller (44:d4:37:ac:a4:70), Dst: EasyMesh:Agent (46:d4:37:97:a8:40)
  IEEE 1905.1a
    Message version: 0
    Message reserved: 0
    Message type: AP autoconfiguration response (0x0008)
    Message id: 0x9b94
    Fragment id: 0x00
    > Flags: 0x80, Last fragment
    < SupportedRole
      TLV type: SupportedRole (0x0f)
      > TLV length: 1
      Supported role: 0x00, Registrar
    < SupportedFreqBand
      TLV type: SupportedFreqBand (0x10)
      > TLV length: 1
      Supported frequency band: 0x01, 802.11 5 GHz
    < Supported service information
      TLV type: Supported service information (0x80)
      > TLV length: 2
      Supported service count: 1
      < Supported service list
        Supported service: 0x00, Multi-AP Controller
    < Multi AP Profile
      TLV type: Multi AP Profile (0xb3)
      > TLV length: 1
      Multi-AP Profile: Multi-AP Profile 2 (2)
    < End of message
```



EasyMesh unter der Haube: Autoconfig M1

```
No. | Time | Source | Destination | Protocol | Length | Info
---|---|---|---|---|---|---
12 5.537392 EasyMesh:Agent EasyMesh:Controller ieee1905 449 AP autoconfiguration Wi-Fi simple configuration (WSC), M1
13 5.621126 EasyMesh:Agent EasyMesh:Controller ieee1905 425 AP autoconfiguration Wi-Fi simple configuration (WSC), M1

> Frame 12: 449 bytes on wire (3592 bits), 449 bytes captured (3592 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Agent (44:d4:37:97:a8:40), Dst: EasyMesh:Controller (46:d4:37:ac:a4:70)
< IEEE 1905.1a
  Message version: 0
  Message reserved: 0
  Message type: AP autoconfiguration Wi-Fi simple configuration (WSC) (0x0009)
  Message id: 0x9b96
  Fragment id: 0x00
  Flags: 0x00, Last fragment
  WSC
    TLV type: WSC (0x11)
    TLV length: 357
    Version: 0x10
    Message Type: M1 (0x04)
    UUID E
    MAC Address
    Enrollee Nonce
    Public Key
    Authentication Type Flags: 0x007b
    Encryption Type Flags: 0x0000
    Connection Type Flags: ESS (0x01)
    Config Methods: 0x0680
  Wifi Protected Setup State: Not configured (0x01)
    Data Element Type: Wifi Protected Setup State (0x1044)
    Data Element Length: 1
    Wifi Protected Setup State: Not configured (0x01)
  Manufacturer:
  Model Name:
  Model Number:
  Serial Number:
  Primary Device Type
  Device Name:
  RF Bands: 5 GHz (0x02)
  Association State: Not associated (0x0000)
  Device Password ID: PushButton (0x0004)
  Configuration Error: No Error (0x0000)
  OS Version: 0x00000000
  Vendor Extension
  AP Radio Advanced Capabilities
    TLV type: AP Radio Advanced Capabilities (0xbe)
    TLV length: 7
    Radio Unique ID: IntenoBr_97:a8:4f (44:d4:37:97:a8:4f)
    AP Radio Advanced Capabilities Flags: 0x40, Traffic Separation on combined R1 and R2 and above backhaul
  AP radio basic capabilities
    TLV type: AP radio basic capabilities (0x85)
    TLV length: 41
    AP radio identifier: 44d43797a84f
    Maximum BSS support: 16
    Operating class count: 11
    Supported operating classes list
  Profile 2 AP Capability
    TLV type: Profile 2 AP Capability (0xb4)
    TLV length: 4
    Max Total Number Service Prioritization Rules: 0
    Reserved: 0x00
    Flags: 0x00, Byte Counter Units: bytes
    Max Total Number of VIDs: 255
  End of message
```

EasyMesh unter der Haube: Autoconfig M2 - Konfiguration



```
No. | Time | Source | Destination | Protocol | Length | Info
---|---|---|---|---|---|---
20 | 5.937705 | EasyMesh:Controller | EasyMesh:Agent | IEEE1905 | 1039 | AP autoconfiguration Wi-Fi simple configuration (WSC), M2, M2

> Frame 20: 1039 bytes on wire (8312 bits), 1039 bytes captured (8312 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Controller (44:d4:37:ac:a4:70), Dst: EasyMesh:Agent (46:d4:37:97:a8:140)
< IEEE 1905.1a
  Message version: 0
  Message reserved: 0
  Message type: AP autoconfiguration Wi-Fi simple configuration (WSC) (0x0009)
  Message id: 0x9b97
  Fragment id: 0x00
  > Flags: 0x80, Last fragment
  > AP radio identifier
  < WSC
    > TLV type: WSC (0x11)
    > TLV length: 506
    > Version: 0x10
    > Message Type: M2 (0x05)
    > Enrollee Nonce
    > Registrar Nonce
    > UUID R
    > Public Key
    > Authentication Type Flags: 0x0040
    > Encryption Type Flags: 0x0008
    > Connection Type Flags: ESS (0x01)
    > Config Methods: 0x0680
    > Manufacturer:
    > Model Name:
    > Model Number:
    > Serial Number:
    > Primary Device Type
    > Device Name:
    > RF Bands: 2.4 GHz (0x01)
    > Association State: Connection success (0x0001)
    > Configuration Error: No Error (0x0000)
    > Device Password ID: PushButton (0x0004)
    > OS Version: 0x80000000
    > Vendor Extension
    > Encrypted Settings
    > < Encrypted Settings
  < WSC
    > TLV type: WSC (0x11)
    > TLV length: 490
    > Version: 0x10
    > Message Type: M2 (0x05)
    > Enrollee Nonce
    > Registrar Nonce
    > UUID R
    > Public Key
    > Authentication Type Flags: 0x0060
    > Encryption Type Flags: 0x0008
    > Connection Type Flags: ESS (0x01)
    > Config Methods: 0x0680
    > Manufacturer:
    > Model Name:
    > Model Number:
    > Serial Number:
    > Primary Device Type
    > Device Name:
    > RF Bands: 2.4 GHz (0x01)
    > Association State: Connection success (0x0001)
    > Configuration Error: No Error (0x0000)
    > Device Password ID: PushButton (0x0004)
    > OS Version: 0x80000000
    > Vendor Extension
    > Encrypted Settings
    > < Encrypted Settings
  < End of message
```



EasyMesh unter der Haube: Link Metriken

No.	Time	Source	Destination	Protocol	Length	Info
39	12.174264	EasyMesh:Controller	EasyMesh:Agent	ieee1905	60	Link metric query
40	12.180367	EasyMesh:Agent	EasyMesh:Controller	ieee1905	267	Topology response
41	12.180841	EasyMesh:Agent	EasyMesh:Controller	ieee1905	455	Topology response
42	12.182184	EasyMesh:Agent	EasyMesh:Controller	ieee1905	60	Operating Channel Report
43	12.182455	EasyMesh:Agent	EasyMesh:Controller	ieee1905	484	Higher layer response
44	12.183269	EasyMesh:Agent	EasyMesh:Controller	ieee1905	110	Link metric response


```
> Frame 39: 60 bytes on wire (480 bits), 60 bytes captured (480 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Controller (44:d4:37:ac:a4:70), Dst: EasyMesh:Agent (46:d4:37:97:a8:40)
< IEEE 1905.1a
  Message version: 0
  Message reserved: 0
  Message type: Link metric query (0x0005)
  Message id: 0x9d9a
  Fragment id: 0x00
  > Flags: 0x80, Last fragment
  < Link metric query
    TLV type: Link metric query (0x08)
    > TLV length: 8
    Link metric query type: All neighbors (0)
    Link metrics requested: Tx link metrics only (0)
  > End of message
```




EasyMesh unter der Haube: Link Metriken

No.	Time	Source	Destination	Protocol	Length	Info
44	12.183269	EasyMesh:Agent	EasyMesh:Controller	ieee1905	110	Link metric response
45	12.383101	EasyMesh:Controller	EasyMesh:Agent	ieee1905	60	AP Capability Query
46	12.384880	EasyMesh:Agent	EasyMesh:Controller	ieee1905	458	AP Capability Report
47	12.586151	EasyMesh:Controller	EasyMesh:Agent	ieee1905	74	AP Metrics Query
48	12.587434	EasyMesh:Agent	EasyMesh:Controller	ieee1905	250	AP Metrics Response
49	12.788264	EasyMesh:Controller	EasyMesh:Agent	ieee1905	60	Backhaul STA Capability Query


```
> Frame 44: 110 bytes on wire (880 bits), 110 bytes captured (880 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Agent (44:d4:37:97:a8:40), Dst: EasyMesh:Controller (46:d4:37:ac:a4:70)
  IEEE 1905.1a
    Message version: 0
    Message reserved: 0
    Message type: Link metric response (0x0006)
    Message id: 0x9d9a
    Fragment id: 0x00
    > Flags: 0x80, Last fragment
  < 1905 transmitter link metric
    TLV type: 1905 transmitter link metric (0x09)
    > TLV length: 41
    Responder MAC address: EasyMesh:Agent (46:d4:37:97:a8:40)
    Neighbor MAC address: EasyMesh:Controller (46:d4:37:ac:a4:70)
    Receiving AL MAC address: EasyMesh:Agent (44:d4:37:97:a8:40)
    Neighbor MAC address: EasyMesh:Controller (44:d4:37:ac:a4:70)
    > Media type: 0x0001, IEEE 802.3ab gigabit
    IEEE 802.1 bridge flag: 1905 link includes one or more IEEE 802.1 bridges (1)
    Packet errors: 0
    Transmitted packets: 81
    MAC throughput capacity: 0
    Link availability: 100
    Phy rate: 0
  < 1905 receiver link metric
    TLV type: 1905 receiver link metric (0x0a)
    > TLV length: 35
    Responder MAC address: EasyMesh:Agent (46:d4:37:97:a8:40)
    Neighbor MAC address: EasyMesh:Controller (46:d4:37:ac:a4:70)
    Receiving AL MAC address: EasyMesh:Agent (44:d4:37:97:a8:40)
    Neighbor MAC address: EasyMesh:Controller (44:d4:37:ac:a4:70)
    > Media type: 0x0001, IEEE 802.3ab gigabit
    Packet errors: 0
    Packets received: 0
    RSSI: 0xff
```



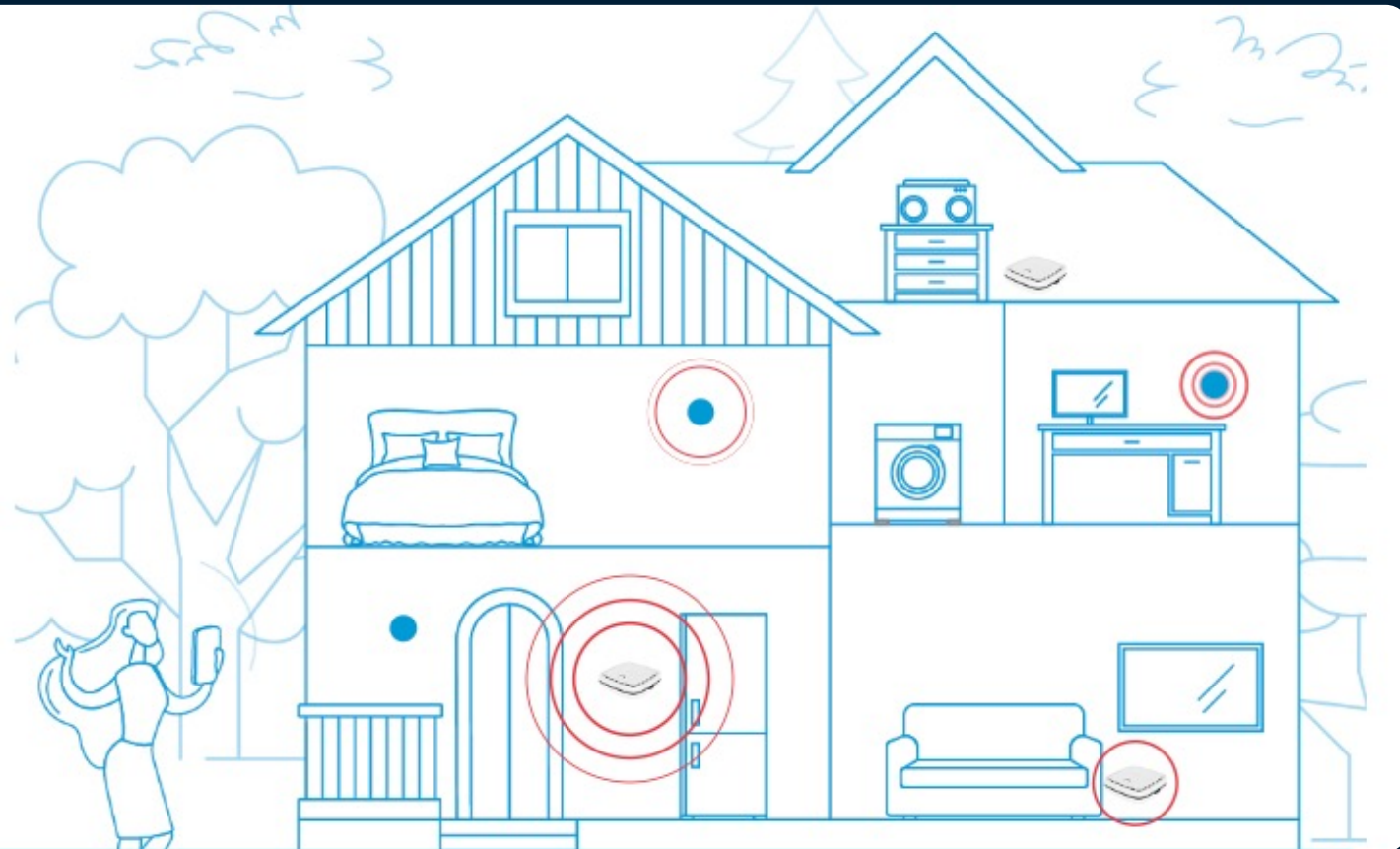
EasyMesh unter der Haube: AP Metriken

```
|Time|Source|Destination|Protocol|Length|Info
8 12.587434 EasyMesh:Agent EasyMesh:Controller ieee1905 250 AP Metrics Response

> Frame 48: 250 bytes on wire (2000 bits), 250 bytes captured (2000 bits) on interface en6, id 0
> Ethernet II, Src: EasyMesh:Agent (44:d4:37:97:a8:40), Dst: EasyMesh:Controller (46:d4:37:ac:a4:70)
< IEEE 1905.1a
  Message version: 0
  Message reserved: 0
  Message type: AP Metrics Response (0x800c)
  Message id: 0x9da0
  Fragment id: 0x00
  > Flags: 0x80, Last fragment
  < Radio Metrics
    TLV type: Radio Metrics (0xc6)
    > TLV length: 10
    Radio unique ID: 44d43797a84f
    Noise: 168
    Transmit: 56
    ReceiveSelf: 0
    ReceiveOther: 68
  < Radio Metrics
    TLV type: Radio Metrics (0xc6)
    > TLV length: 10
    Radio unique ID: 44d43797a84e
    Noise: 174
    Transmit: 156
    ReceiveSelf: 0
    ReceiveOther: 12
  < AP metrics
    TLV type: AP metrics (0x94)
    > TLV length: 13
    Multi-AP agent BSSID: 3ed43797a849
    Channel utilization: 80
    BSS STA count: 0
    > Estimated Service Parameters Flags: 0x80
    Estimated service parameters AC=BE: 000000
  < AP Extended Metrics
    TLV type: AP Extended Metrics (0xc7)
    > TLV length: 30
    BSSID: 3e:d4:37:97:a8:49 (3e:d4:37:97:a8:49)
    UnicastBytesSent: 0
    UnicastBytesReceived: 0
    MulticastBytesSent: 24
    MulticastBytesReceived: 0
    BroadcastBytesSent: 5
    BroadcastBytesReceived: 0
  > AP metrics
  > AP Extended Metrics
  > AP metrics
  > AP Extended Metrics
  > AP metrics
  > AP Extended Metrics
  > End of message
```



EasyMesh Inbetriebnahme



EasyMesh: Inbetriebnahme



**Gateway in Betrieb
nehmen**

ggf. Netzwerkprofil(e) ändern



Mein Netzwerk



EasyMesh: Inbetriebnahme



Gateway in Betrieb nehmen

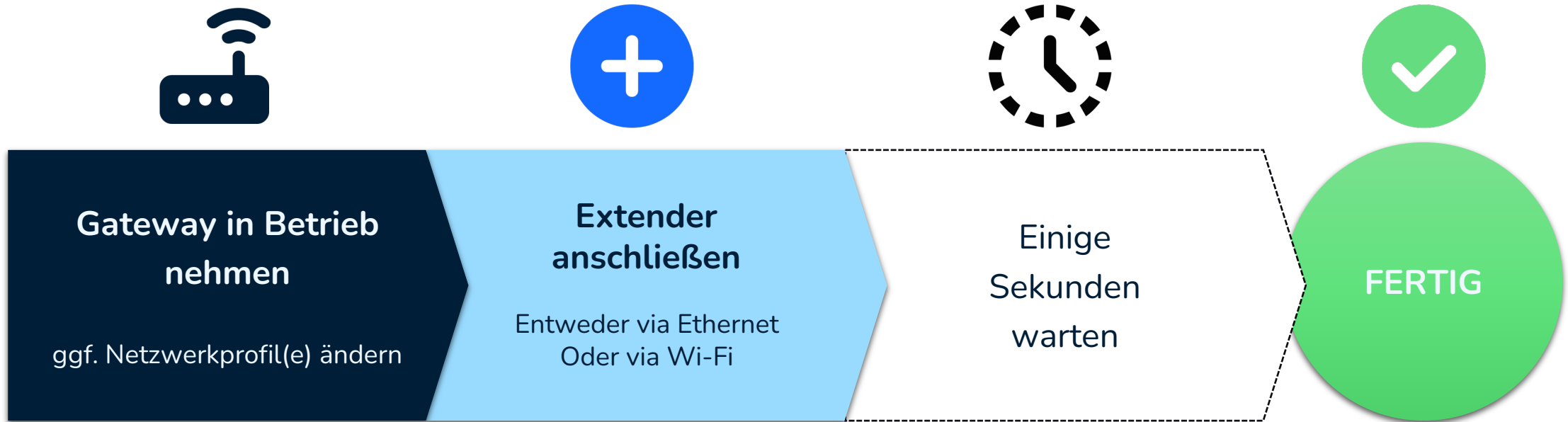
ggf. Netzwerkprofil(e) ändern

Extender anschließen

Entweder via Ethernet
Oder via Wi-Fi

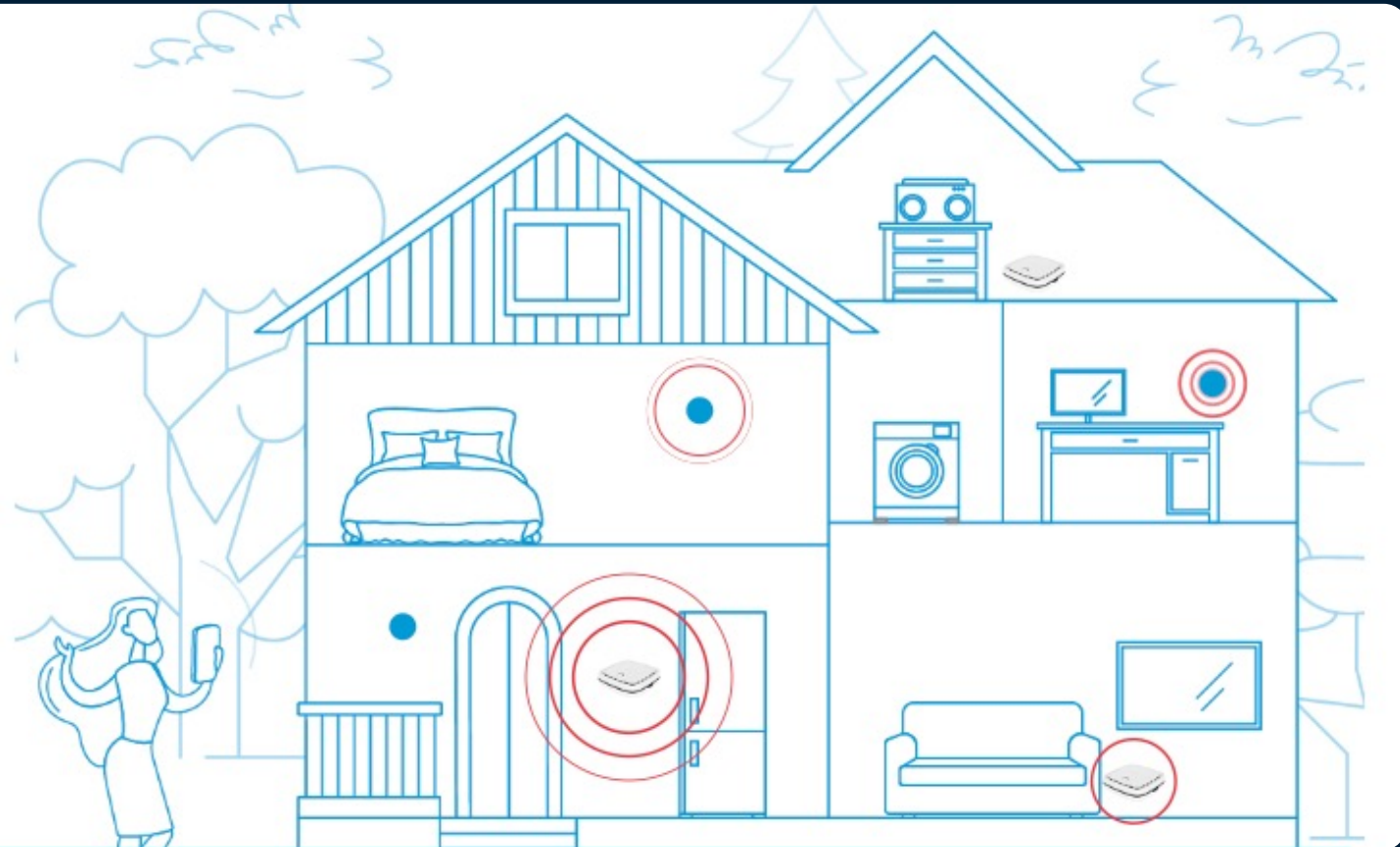


EasyMesh: Inbetriebnahme





EasyMesh Management & Diagnose





Problem

Konfiguration sowie Informations- & Diagnosedaten proprietär



Problem

Einstellungsmöglichkeiten und Diagnosedaten verschiedener Hersteller lassen sich nur schwer oder gar nicht vergleichen



Problem

Eingabe und/oder Abruf der Daten erfolgt bei jedem Hersteller unterschiedlich, Formate der Daten unterscheiden sich



Lösung

Wi-Fi Data Elements

EasyMesh: Data Elements



**Standardisiertes
Datenmodell mit >250
KPIs**

AP & Client Fähigkeiten,
Diagnose, Optimierung

**Einheitlicher Satz von
Diagnosedaten**

**Einheitlicher Satz an
Konfigurationsoptionen
(v2.1)**

Beispiele:
Roamingschwellwert,
Wi-Fi 6 Spatial Re-Use

**Datenformat ist
vorgegeben**

Beispiel: Signalstärke in
dBm oder %

**Datenangaben sind für
alle Hersteller
identisch**

Beispiel: Signalstärke
als RSSI oder RCPI

**Kommunikation im
JSON-Format via
HTTP(S) ist
vorgegeben**

Auslesen der Daten von extern
Setzen der Parameter für
unterstützte
Konfigurationsoptionen

EasyMesh: Data Elements

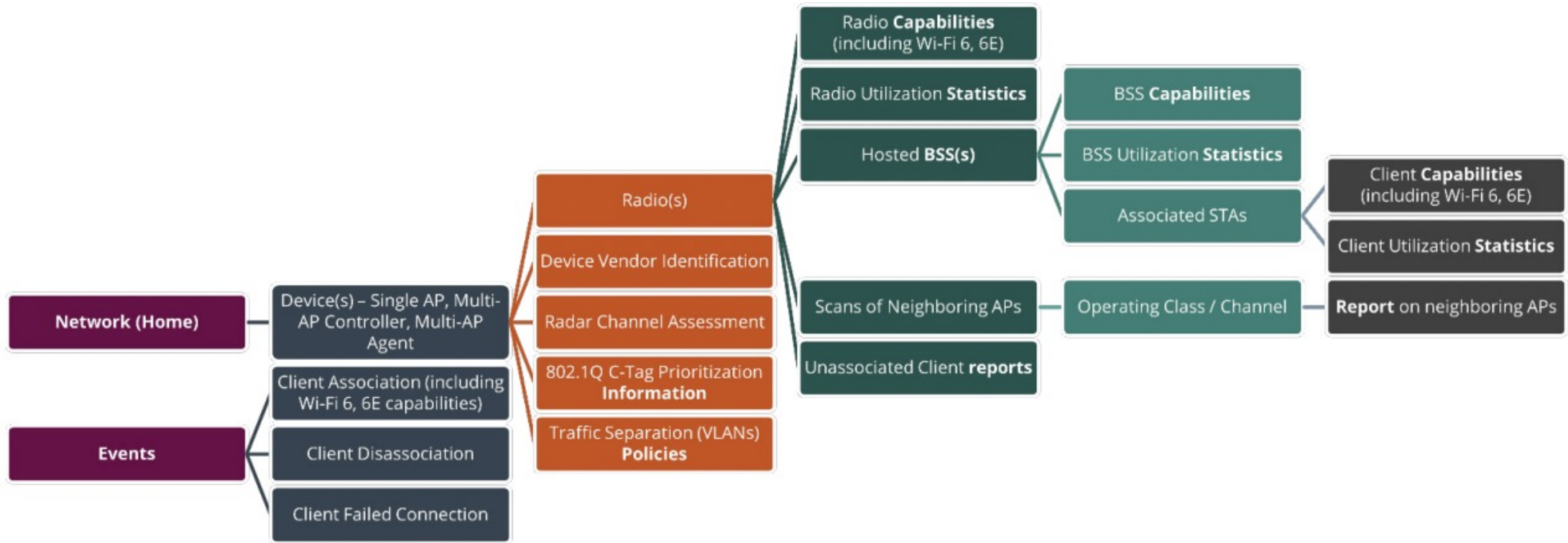


Figure 2. Wi-Fi Data Elements model organization

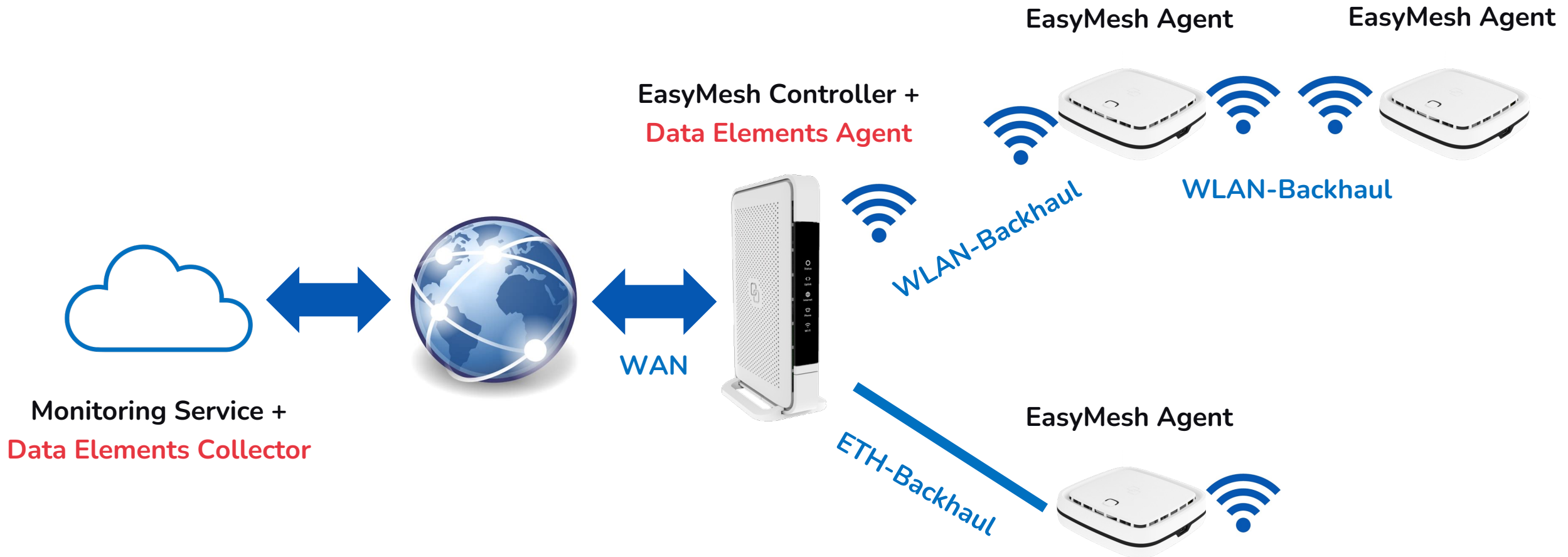


EasyMesh: Data Elements – Beispiele





EasyMesh: Data Elements im EasyMesh Szenario





EasyMesh

Zusammenfassung
& Ausblick





Zusammenfassung und Ausblick

- EasyMesh bietet einfache Konfiguration und umfangreiche Diagnosemöglichkeiten
- Einsatz von EasyMesh auch in kleinen Unternehmen denkbar
- Internetanbieter mit „Dual-Source“-Strategie benötigen Interoperabilität
- Kontinuierliche Weiterentwicklung im EasyMesh zeugt von hoher Marktrelevanz
 - Zunahme von RFIs & RFQs mit EasyMesh als Voraussetzung
 - Die nächsten Features sind bereits in der Pipeline





Vielen Dank für eure Aufmerksamkeit!