Medical Devices Profile for Web Services

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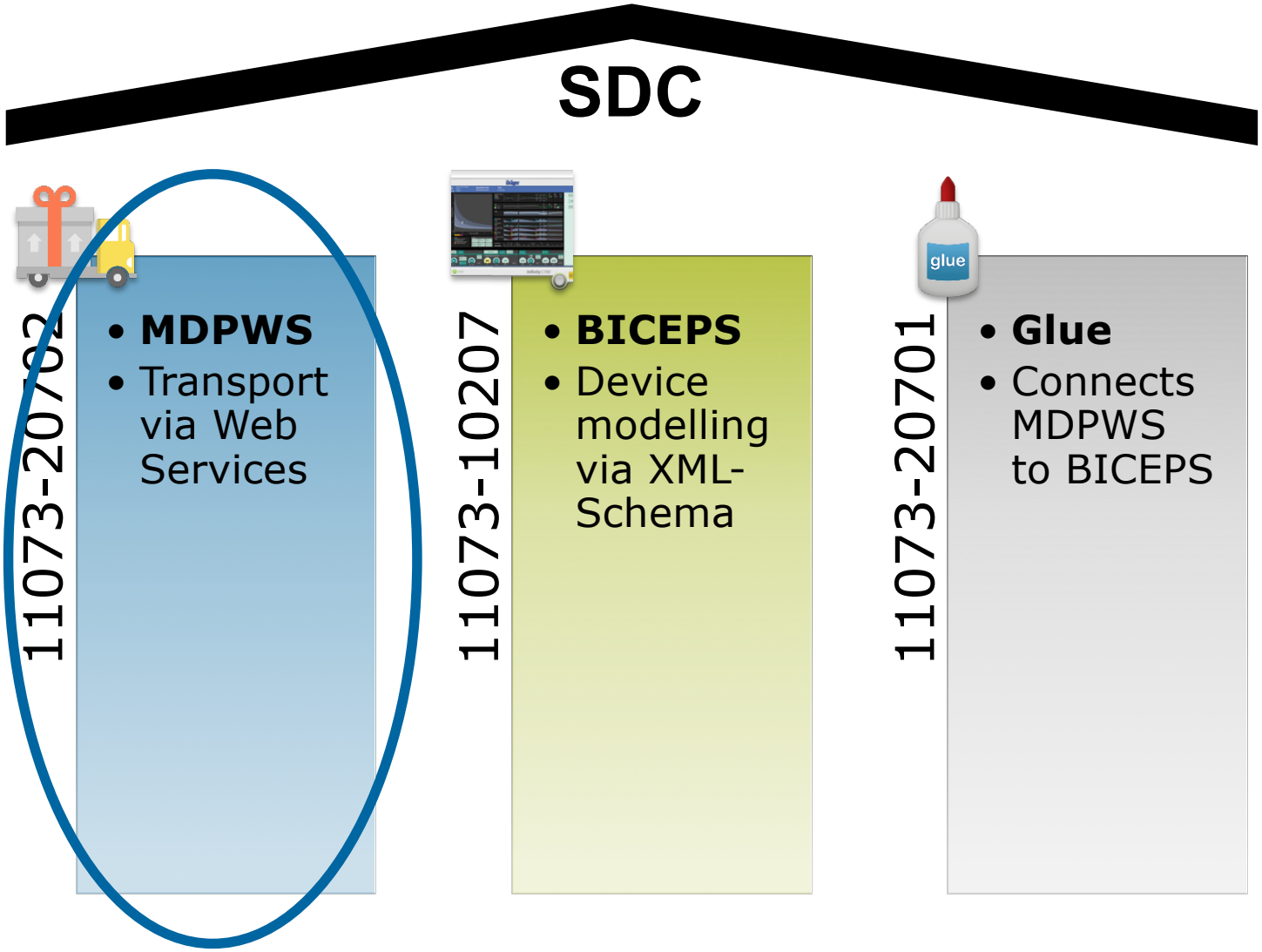
Orientation



Identifying technology

Objective

- Designate a technology for IP based medical device connectivity

Requirements

- Safe and reliable data transfer
- Streaming capabilities
- Interoperability
  - Open standards
  - Widely adopted standards
- Dynamic connection establishment
  - Almost no knowledge of runtime environment
  - Plug-and-play capabilities

Identifying technology

- No middleware technology met all requirements
- However, a case study revealed that there was a candidate worth take into scope
  - *Devices Profile for Web Services*
- We decided to use that profile as a basic middleware technology and extended it to support streaming, safety capabilities, etc.
  - *Medical Devices Profile for Web Services*

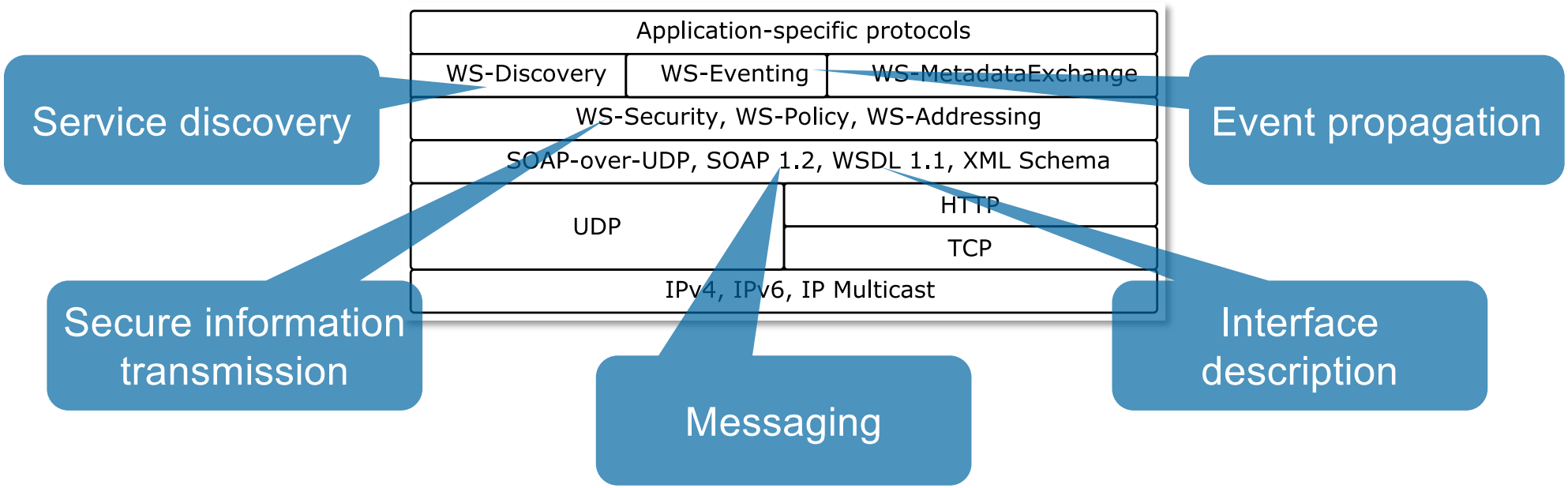
Devices Profile for Web Services

DPWS

DPWS
Overview

- OASIS standard (07/2009)
- Utilizes a subset of WS-* standards
- Designed for resource-constrained devices

→ DPWS provides plug-and play between devices that are connected via IP networks.

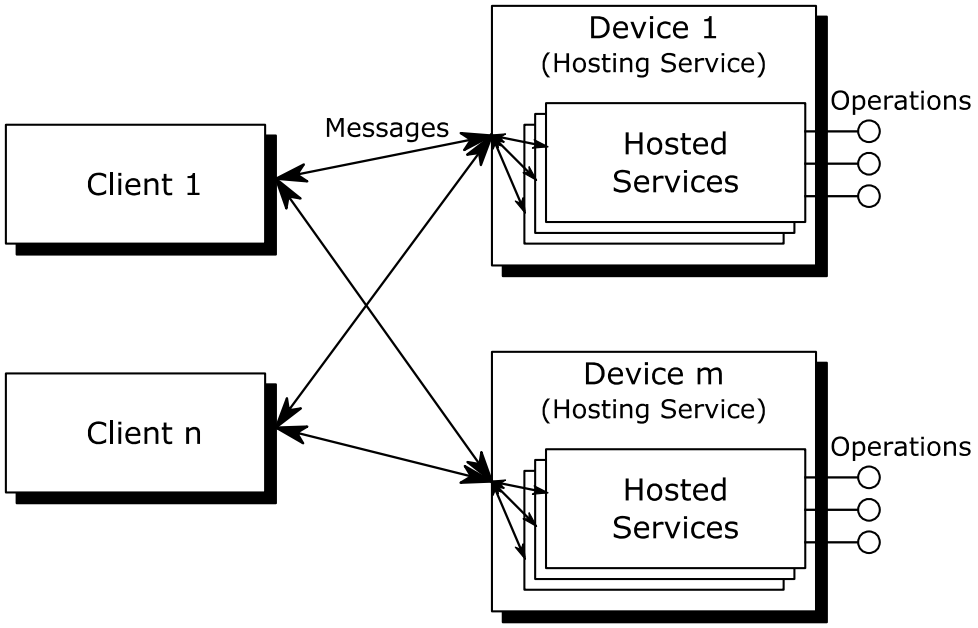


DPWS
Terms

- Device (aka Hosting Service)
  - Provides a set of Services (aka Hosted Service)
- Client
  - Requests Hosting Services to retrieve Hosted Services, on which they can invoke Operations

From a client-server perspective, the *Device* can be considered as a server, and the *Client* can be considered as a client.

However, *Device* and *Client* in terms of DPWS are able to switch roles. Hence, every *Device* can act as a client and vice versa.



DPWS
Messaging

- DPWS is based on Web Services, hence messaging is established by using SOAP documents
- DPWS supports Request-Response and Notification message exchange patterns
- A SOAP message exchanged via DPWS has the following simplified format

```
<?xml version="1.0"?>
<SOAP-ENV:Envelope
  xmlns:SOAP-ENV="http://www.w3.org/2001/12/soap-envelope"
  SOAP-ENV:encodingStyle="http://www.w3.org/2001/12/soap-encoding">
    <SOAP-ENV:Header>
        ...
    </SOAP-ENV:Header>
    <SOAP-ENV:Body>
      ...
    </SOAP-ENV:Body>
</SOAP-ENV:Envelope>
```

DPWS
Messaging

Moreover, DPWS makes use of WS-Addressing

```
<?xml version="1.0"?>
<SOAP-ENV:Envelope xmlns:wsa=http://www.w3.org/2005/08/addressing ...>
  <SOAP-ENV:Header>
    <wsa:MessageID>urn:uuid:4eb70ba5-1f7a-4843-86df-977f92e8cf46</wsa:MessageID>
    <wsa:RelatesTo>urn:uuid:f3b70c20-1c5f-11e7-808d-c247d6c531f6</wsa:RelatesTo>
    <wsa:To>http://www.w3.org/2005/08/addressing/anonymous</wsa:To>
    <wsa5:Action>http://any-action-uri</wsa5:Action>
   </SOAP-ENV:Header>
...
```

DPWS
Discovery of Devices

DPWS uses WS-Discovery for implicit and explicit discovery

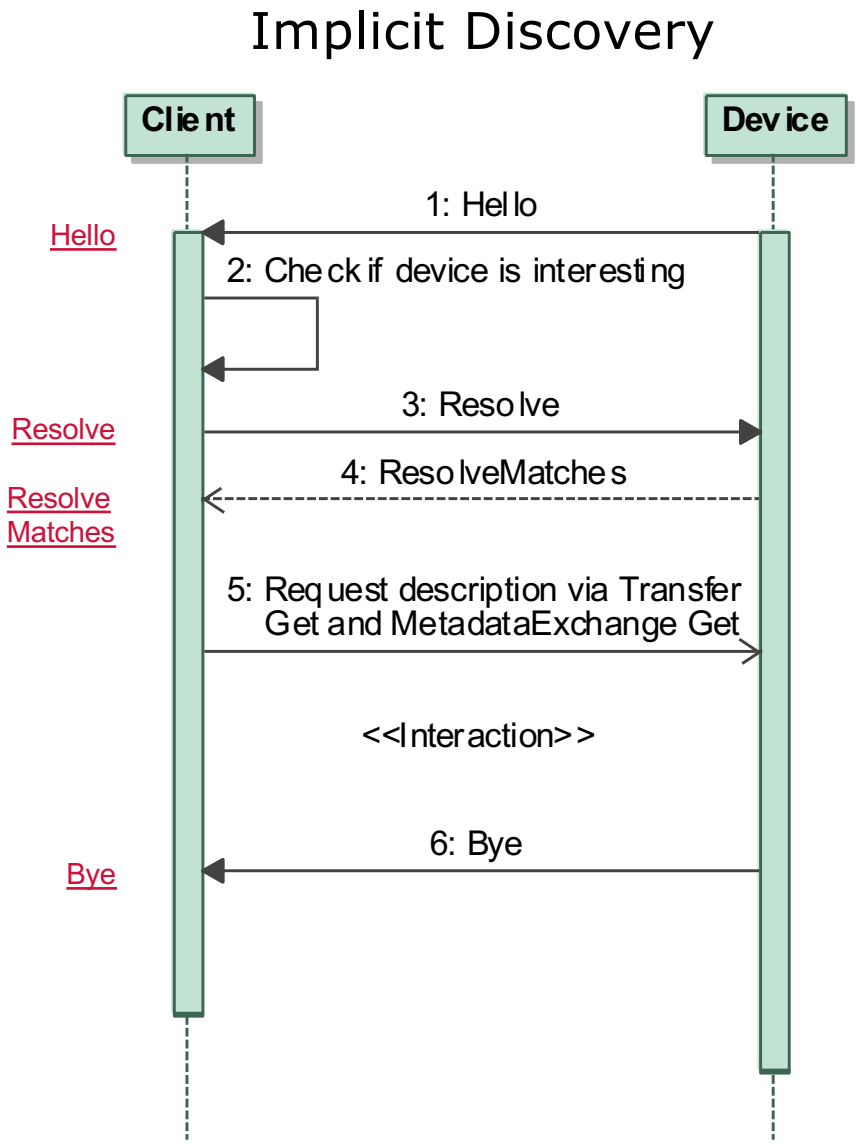
- Implicit discovery
  - A Device announces its presence to Clients through Hello and Bye messages
- Explicit discovery
  - A Client actively searches for Devices through Probe messages

DPWS
Discovery of Devices

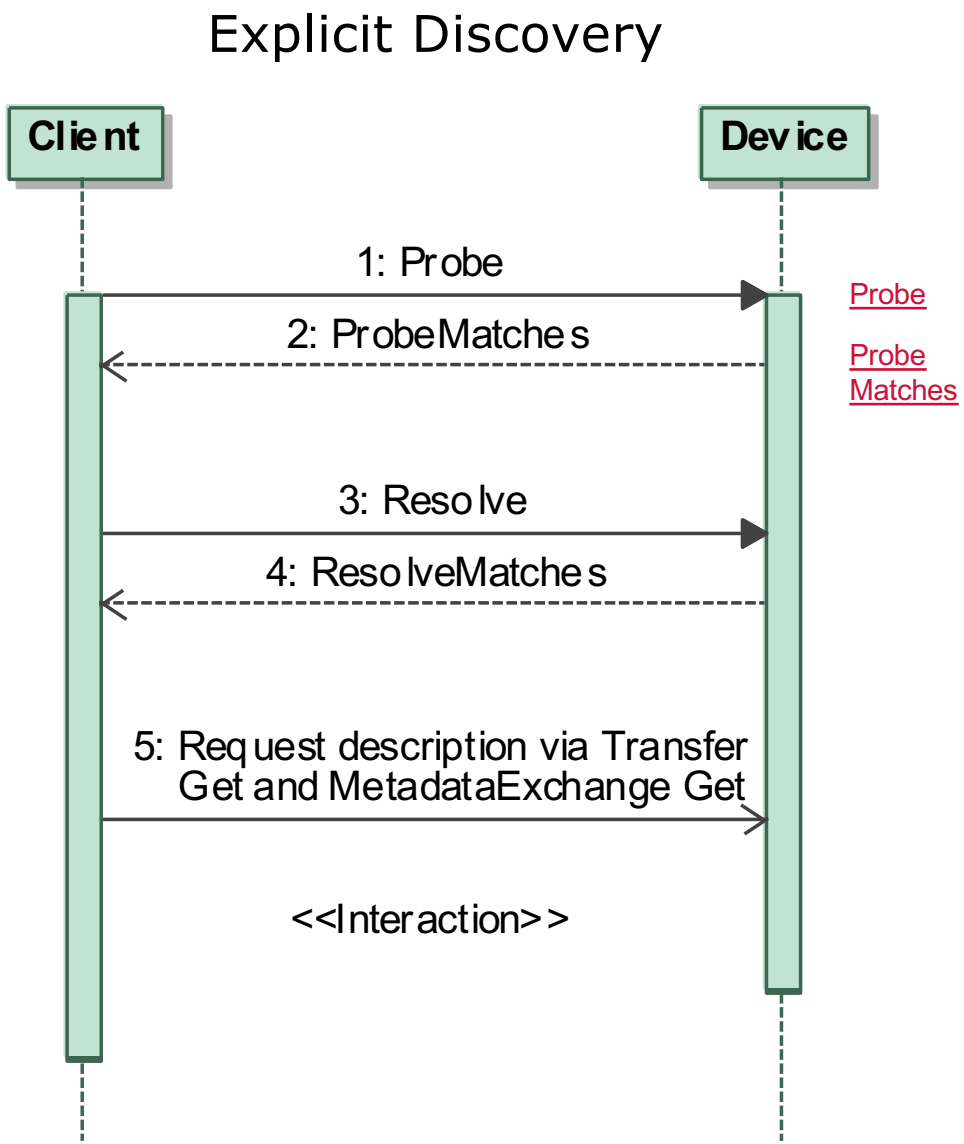
- Discovery is based on list of Types (QNames) and Scopes (URIs)
- WS-Discovery uses UDP, so one can use Wireshark to investigate message transfer on port 3702
  - IPv4 multicast address: 239.255.255.250
  - IPv6 multicast address: FF02::C

Note: In WS-Discovery speech a Client probes for Target Services. Transferred to DPWS a Target Service can be considered as the Device (aka Hosting Service).

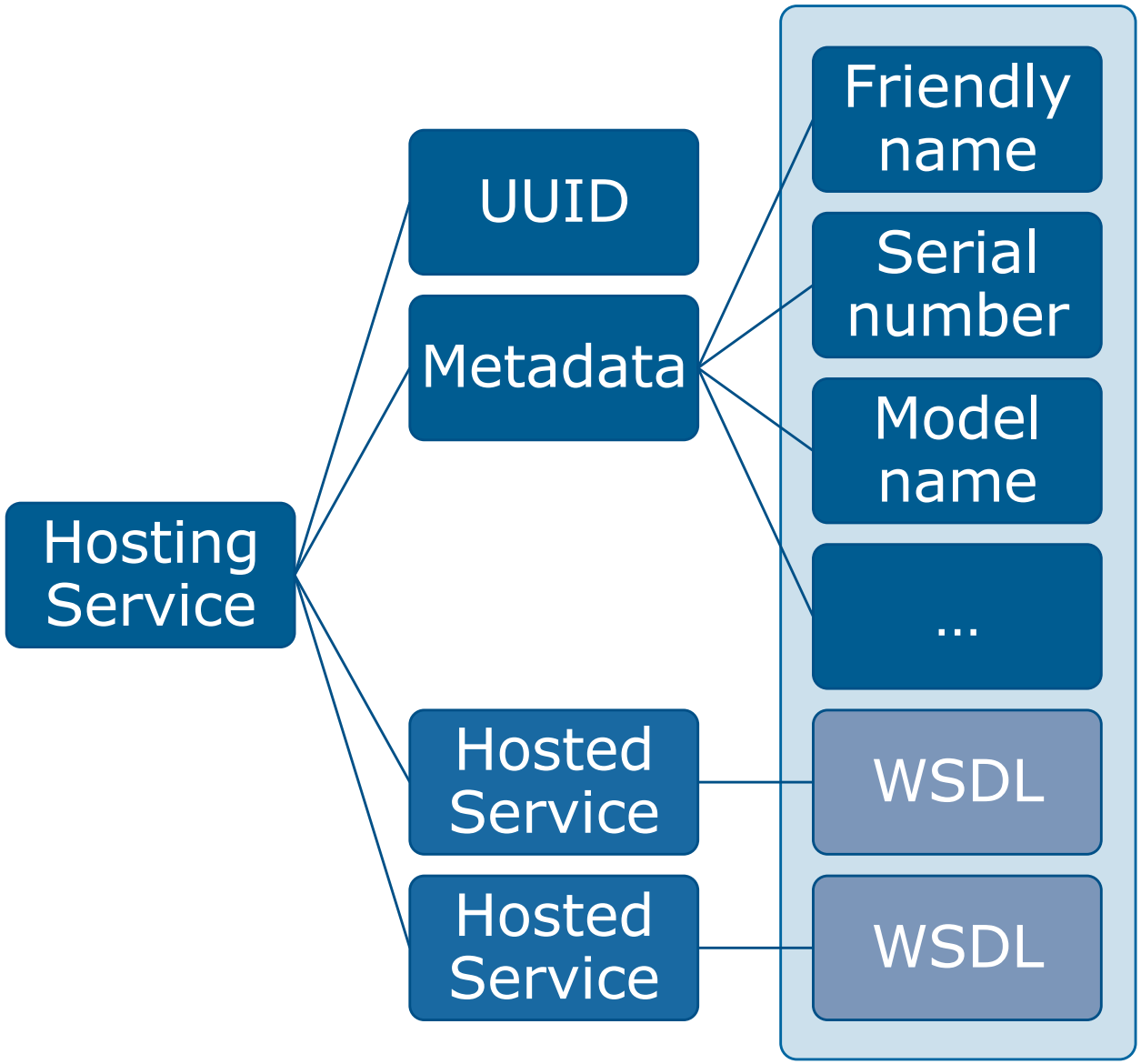
DPWS
Discovery of Devices



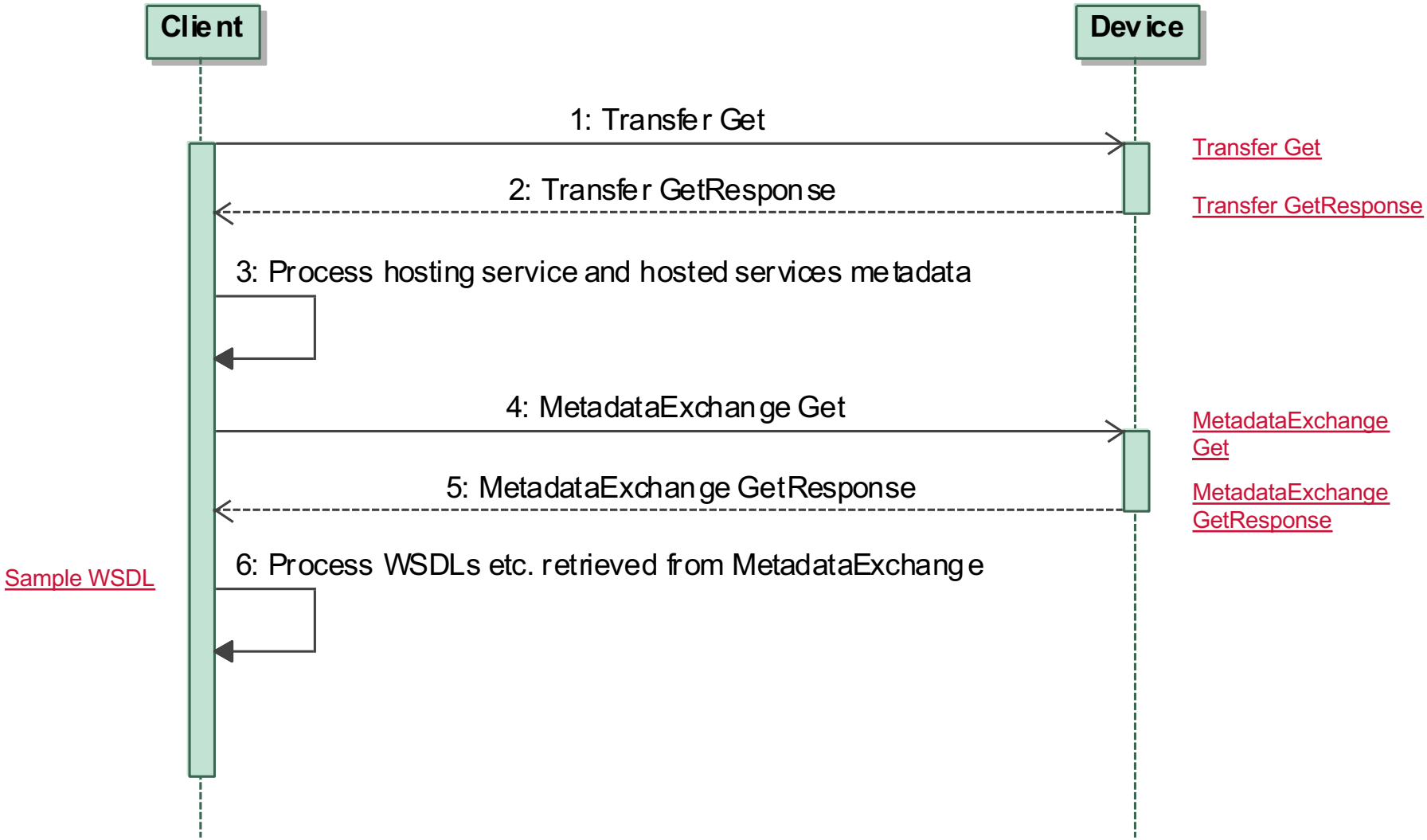
DPWS
Discovery of Devices



DPWS
Interface Description



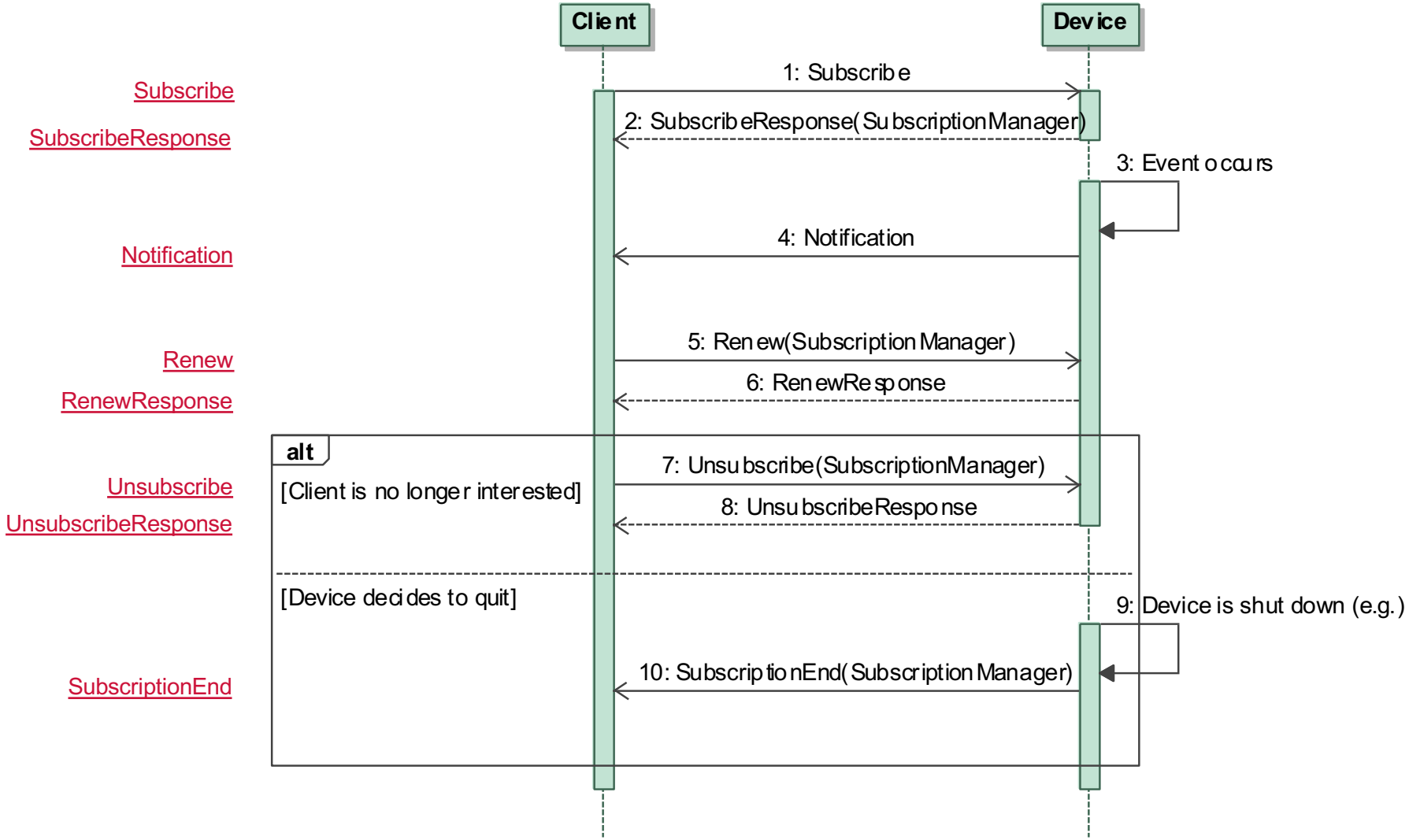
DPWS
Interface Description



DPWS
Event propagation

- In order to support event-driven communication DPWS includes WS-Eventing
- WS-Eventing describes a Web Service-based publish-subscribe pattern
- A Subscription Manager acts as session between an Event Source (aka Hosted Service) and an Event Sink (aka Client)
- After a session is negotiated, the Event Source sends Notifications to the Event Sink

DPWS
Event propagation



DPWS
Secure information transmission

Securing data exchange between Devices and Clients is twofold:

1. Any TCP-based message exchange can be secured using HTTPS (TLS over SSL)
2. Any UDP-based message exchange is not supposed to be encrypted, but may be secured against integrity attacks by using Compact Signatures

→ Authentication only; there is no predefined mechanism to support authorization

DPWS for Medical Devices

MDPWS

MDPWS
Overview

- Numeric data streaming
  - Maybe unreliable
  - Multiple receivers

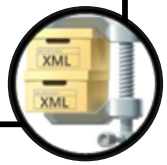
Waveform Streaming

- Safe & reliable data exchange
- Watchdogs

Patient Safety

- Efficient XML Interchange, if needed

Compression

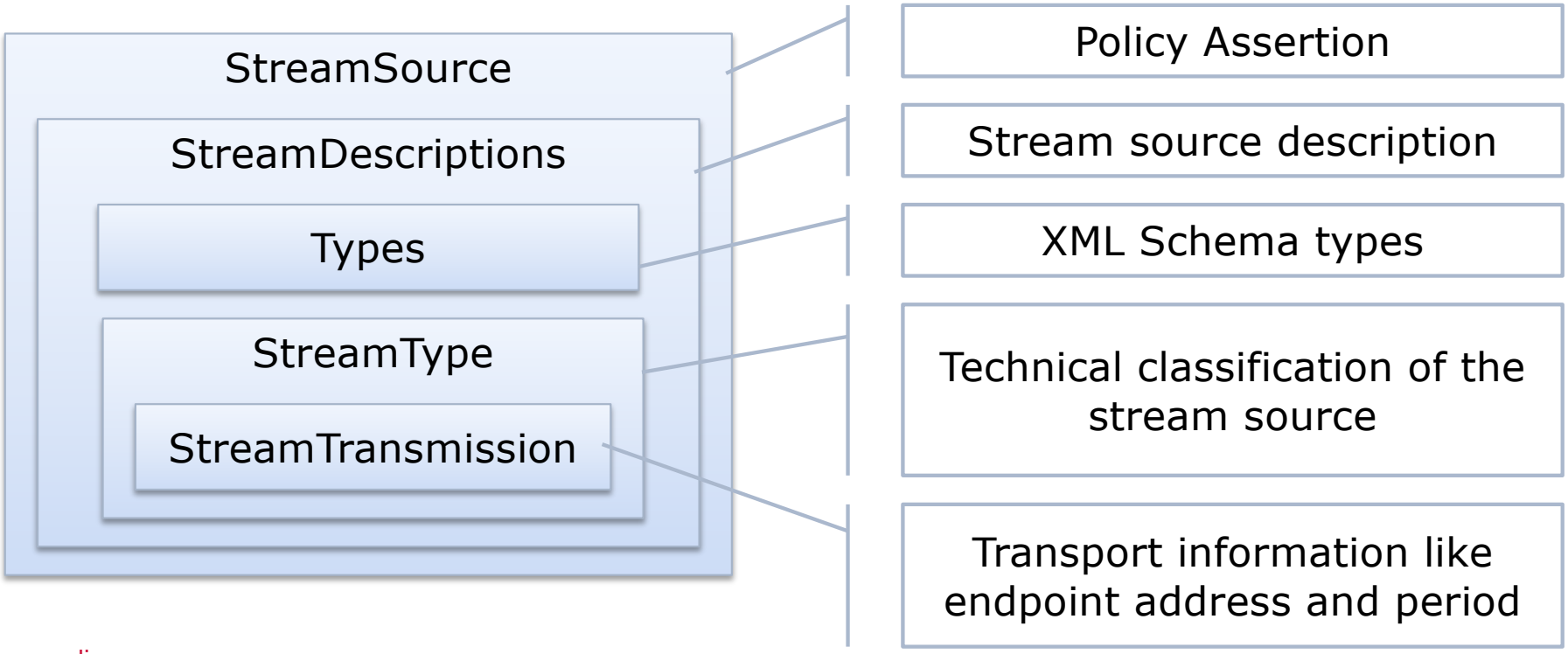


- Policy assertions
- Limit options in DPWS spec
- New Device Type for Discovery

General

MDPWS
Streaming

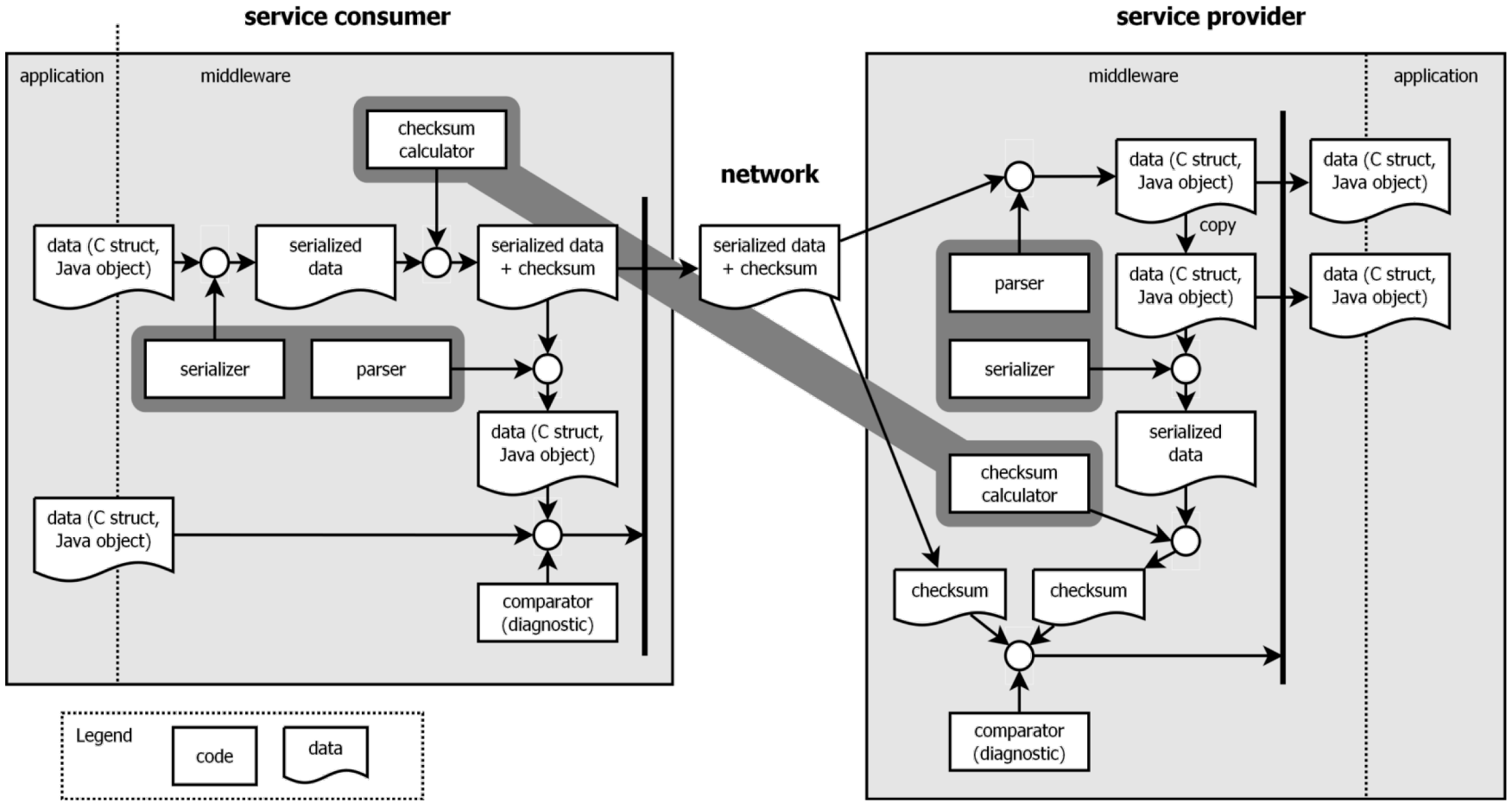
- MDPWS defines a WS-Policy assertion in order to indicate streaming support
- The policy can be embedded into WS-MetadataExchange GetResponse messages



StreamSource policy

MDPWS
Patient Safety – Dual Channel Transmission

- The service provider detects a failure, e.g., by means of an invalid checksum.



MDPWS
Patient Safety – Dual Channel Transmission

- How does it look on the wire?

```
<s12:Envelope ...><s12:Header><wsa:Action>...</wsa:Action><wsa:MessageID>...</wsa:MessageID><wsa:To>...</wsa:To>
    <mdpws:SafetyInfo>
      <mdpws:DualChannel>
        <mdpws:DcValue ReferencedSelector="SELECTOR_1">
          7d836f4befca2bda3e8abb1f7bd93345a5b10ae9
        </mdpws:DcValue>
        <mdpws:DcValue ReferencedSelector="SELECTOR_2">
          8dce170de238b1feda2ecd9674ea3ca0d068fbcb
        </mdpws:DcValue>
      </mdpws:DualChannel>
    </mdpws:SafetyInfo>
  </s12:Header><s12:Body>
    <msg:SetString>
      <msg:OperationHandleRef>
        op1
      </msg:OperationHandleRef>
      <msg:RequestedStringValue>
        Value
      </msg:RequestedStringValue>
    </msg:SetString>
  </s12:Body></s12:Envelope>
```

MDPWS
Patient Safety – Safety Context

- Used in remote control to add contextual information to the operation being executed
- Example
  - Client A wants to change a parameter on device
  - Device B has his current state of the MDIB that can differ from the latest MDIB Client A is synchronized with (→ IP is best effort)
  - When Client A makes an operation call Device B can impose Client A to attach data to the request – like the current value of a setting
  - If that data does not match with Device B‘s last state of that setting, Device B might refuse the request

MDPWS
Patient Safety – Safety Context

- How does it look on the wire?

```
<s12:Envelope ...><s12:Header><wsa:Action>...</wsa:Action><wsa:MessageID>...</wsa:MessageID><wsa:To>...</wsa:To>
    <mdpws:SafetyInfo>
      <mdpws:SafetyContext>
        <mdpws:CtxtValue ReferencedSelector="SELECTOR_3">
          262656
        </mdpws:CtxtValue>
        <mdpws:CtxtValue ReferencedSelector="SELECTOR_4">
          Sample safety context value
        </mdpws:CtxtValue>
      </mdpws:SafetyContext>
    </mdpws:SafetyInfo>
  </s12:Header><s12:Body>
    <msg:SetString>
      <msg:OperationHandleRef>
        op1
      </msg:OperationHandleRef>
      <msg:RequestedStringValue>
        Value
      </msg:RequestedStringValue>
    </msg:SetString>
  </s12:Body></s12:Envelope>
```

Summary

- MDPWS is a Web Service-based solution to facilitate syntactical interoperability for medical device connectivity
- Clients can detect Devices by using WS-Discovery
- DPWS enables publish-subscribe via WS-Eventing, which provides a connection token between an Event Source and Event Sink
- MDPWS enhances DPWS mainly by
  - streaming capabilites
  - safety information
    - dual channel transmission
    - safety context provision

Thank you for your attention!

Contact information

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