WP 3: Architecture: Middlebox Cooperation

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measurement and architecture for a middleboxed internet

measurement | architecture | experimentation

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Agenda

- Overview
- Use Cases and Requirements
- Architecture & Implementations
- Security Analysis
- Publications
- Conclusion

Overview for WP3

- Define ***use cases*** and requirements for architecture
  - Analysis of deployment restrictions
  - Incentives for middlebox cooperation
- Design, implement, and initial test of ***MCP***
- Design a ***flexible transport stack*** to complement MCP
- ***Threat and trust analysis*** of developed protocols

WP3: Tasks Overview

- T3.1: Use Case Analysis and Requirement Definition (M1 - M6)
- T3.2: Design of the MCP (M7 - M24)
- T3.3: Design of a flexible cooperative transport layer (M7 - M30)
- T3.4: Implementation and Testing (M9 - M30)
- T3.5: Threat and Trust Analysis for Middlebox Cooperation (M1 - M30)

<table>
<tr><th>1</th><th>2</th><th>3</th><th>4</th><th>5</th><th>6</th><th>7</th><th>8</th><th>9</th><th>10</th><th>11</th><th>12</th><th>13</th><th>14</th><th>15</th><th>16</th><th>17</th><th>18</th><th>19</th><th>20</th><th>21</th><th>22</th><th>23</th><th>24</th><th>25</th><th>26</th><th>27</th><th>28</th><th>29</th><th>30</th></tr>
<tr><td colspan="6">T3.1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
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<tr><td></td><td></td><td></td><td></td><td></td><td></td><td colspan="24">T3.3</td></tr>
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<tr><td colspan="30">T3.5</td></tr>
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Overview: Who does what

Partner	MM	Task 3.1 Use Case and Requirements	Task 3.2 Design of MCP	Task 3.3 Flexible transport	Task 3.4 Implementation and Testing	Task 3.5 Threat and Trust Analysis
		Done	On going			
1. ETH	18	✓	✓	✓	✓	
2. TID	10	✓	✓	✓		
4. UoA	12	-	✓	✓	✓	
5. ZHAW	18	✓		✓	✓	✓
7. ALU	10	✓	-	✓	✓	✓

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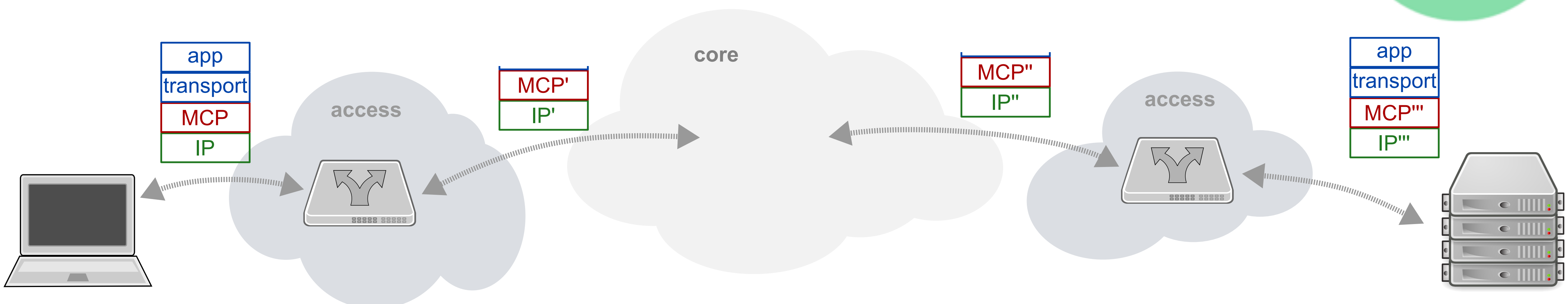
Task 3.1
Use Case Analysis and Requirement Definition

- Derives requirement for the protocol design of MCP
  - Derives protocol extensions to support deployment
  - Identify and coordinate with relating standards activities
- Analysis of the 4 use cases for MCP
- Security Analysis: Trust Model (Zero Trust/Middlebox Authentication) and Attacker Model

- D3.1 is the final outcome of Task 3.1

MCP Design Requirements



- ***Endpoint control*** over cooperation with a clear ***boundary*** between what the path can see and what it cannot, enforced by encryption
- A design that ***deploys*** on the endpoints from day zero
- ***No required trust relationship*** needed between endpoints and middleboxes

Principles v Features

Principle	1	2	3	4	5	6	7	8	9	10	11	12	13
Explicit Cooperation	X	X	X	X							X		X
Declarative Signaling							X	X	X				
Internet Deployability	X					X				X	X	X	X
Mobile Deployability	X					X							
Property Binding	X	X											
Failure Transparency					X								

1= Tube; 2= Sig prop; 3= Path to recv; 4= Recv to send; 5= Path to sender;
6= Tube start; 7= Per packet sig; 8= Declarative signalling; 9= Extensibility;
10= Privacy; 11= Authentication; 12= Integrity; 13= Encrypted feedback

Use cases developed in D3.1

1. Low Latency Support in Mobile Access Networks
2. Throughput Guidance for Congestion Management in Mobile Networks
3. Web Identity Translation (WIT) as a Network Service
4. Multipath Bonding of Mobile and Fixed Network Capacity

1. Low Latency Support in Mobile Access Networks

- **Varying traffic characteristics**: voice, web, messaging, streaming,
  e.g. WebRTC: streams with different characteristics and requirements
- 3GPP networks classify traffic to select appropriate ***bearer for each flow***
  Assumption: 5-tuple represents a single flow with QoS attributes
- ***Opportunistic encryption*** does not provide a proper bearer identification
  Lack of information to perform classification translates into a degradation of mobile network stability and a poorer service to users

Information Exposed

- Declarative signaling of trade-off bt. latency-sensitivity vs. loss-sensitivity
- Indication of maximum acceptable single-hop queueing delay per tube

2. Throughput Guidance for Congestion Management in Mobile Networks

- ***Application-limited, adaptive traffic*** (e.g. streaming video) vs. bandwidth probing
- ***Mobile network knows RAN bandwidth available*** and hence can predict capacity available to any user's mobile device

Information Exposed

- Maximum capacity available to a tube, e.g. similar to QuickStart
- Explicit per-tube indication of the maximum intended data rate

3. Web Identity Translation (WIT) as a Network Service

- Ad agencies' trackers enable a ***free-to-use*** model of web
- Web Identity Translation (WIT) service proxy between users and web-sites, intercepts tracking cookie (in encrypted traffic):

  When a particular user's browsing habits start making her uniquely identifiable, WIT intervenes via private-to-public cookie mappings to restore anonymity in Online Behavioral Advertising (OBA) ecosystem.

Information Exposed

- Visited domains: this data allows building user history vectors
- Cookies: WIT requires cookie access to strip them off during quarantine and manipulate them to allow intervention

4. Multipath Bonding of Mobile and Fixed Network Capacity

- ***Aggregate fixed and mobile capacity***, especially in areas with marginal fixed connectivity, e.g. using MPTCP proxies
- Layer 3 Multipath bonding can handle all traffic (not only TCP) but needs to ***re-order at proxy egress***
- Likely that new protocols will be be (more) robust to re-ordering

Information Exposed

- Reordering sensitivity as a per-tube signal
- Policy indications to the scheduler about which channel is preferred for which tube or packet

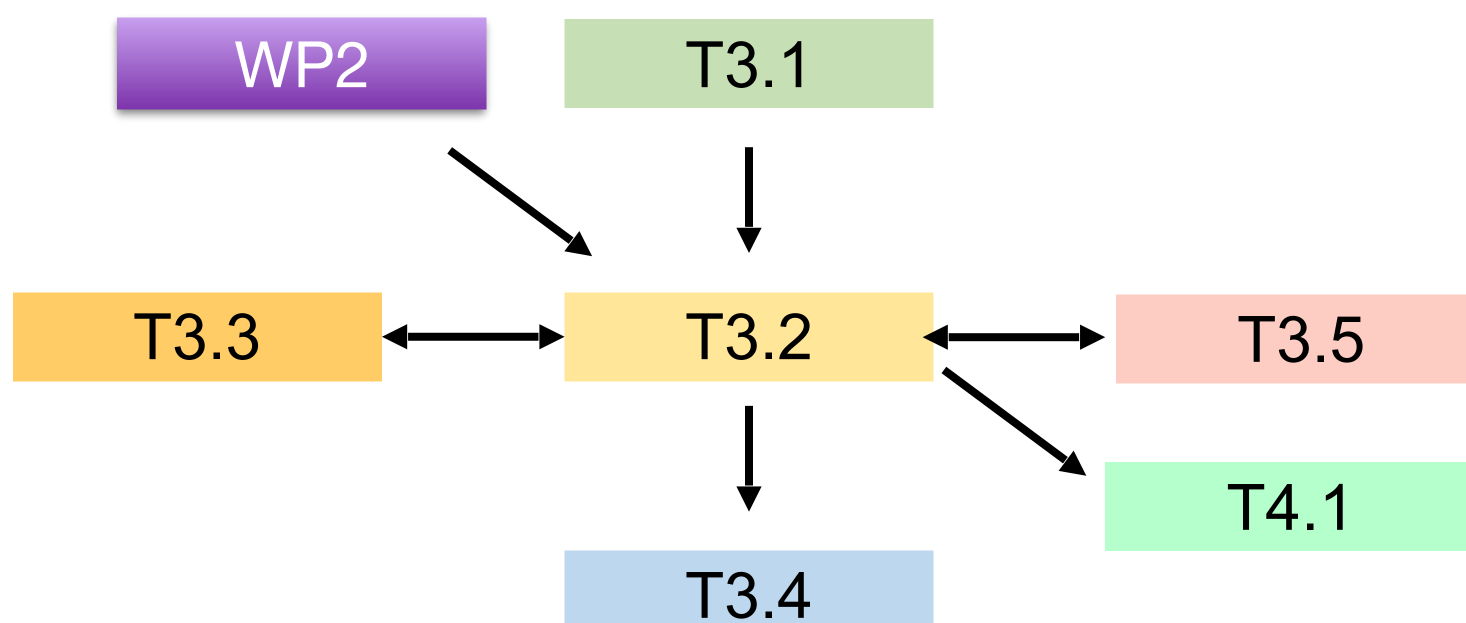
Requirements Related to Use Cases

Principle	1	2	3	4	5	6	7	8	9	10	11	12	13
1. Low Latency Support	X	X					X	X					
2. Throughput Guidance	X	X	X	X	X			X				X	X
3. Web Identity Translation	X	X				X		X		X	X		
4. Multipath Bonding	X	X					X	X					

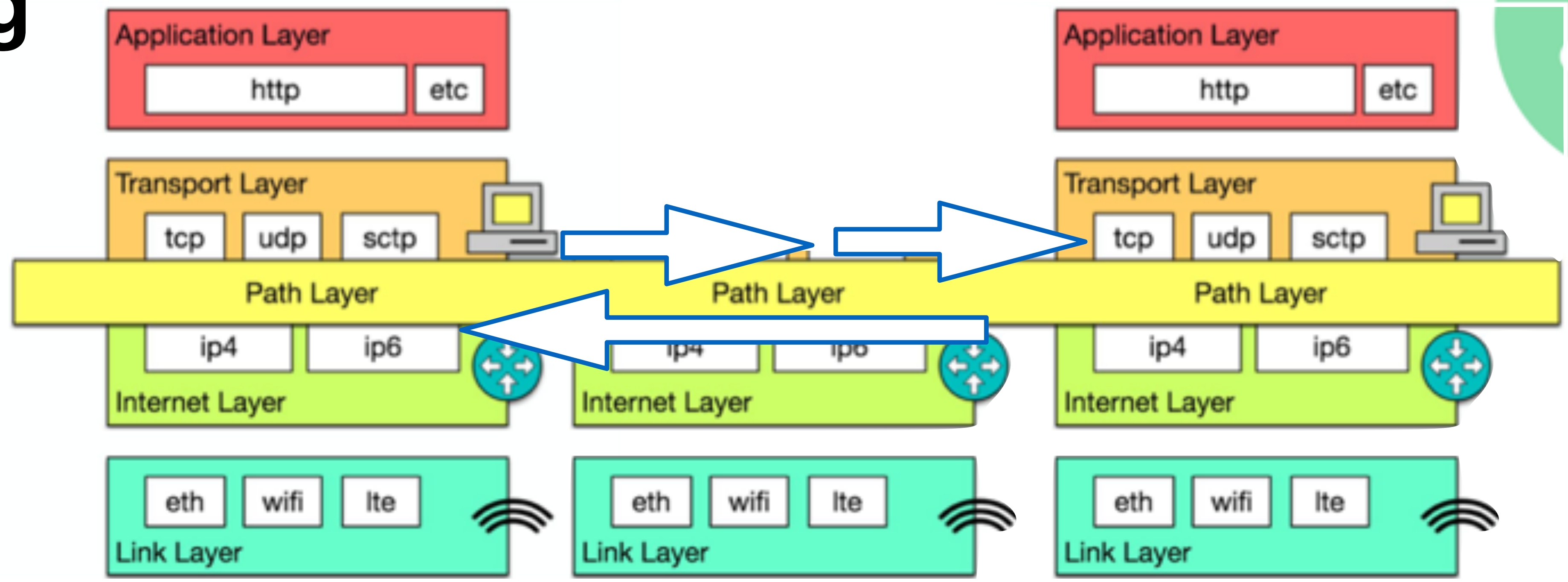
1= Tube; 2= Sig prop; 3= Path to recv; 4= Recv to send; 5= Path to sender; 6= Tube start; 7= Per packet sig; 8= Declarative signalling; 9= Extensibility; 10= Privacy; 11= Authentication; 12= Integrity; 13= Encrypted feedback

T3.2: Design of the MCP - *Started m7*

- Input from T3.1, WP2 (and coexists with T3.3 and T3.5)
- Design a protocol for applications and on-path devices to selectively expose information about traffic and the environment without requiring access to the payload
- Feeds T3.4 to implement, and T4.1 to standardise



Signaling



- **Sender – Path Signaling**
  - Enable ubiquitous deployment of ***encrypted higher layer protocols*** by exposure of basic TCP-like semantics to devices.
  - Applications and transport can ***explicitly provide limited information to devices on path***
- **Path – Receiver & Path – Sender Signaling**
  - Unencrypted ***information about the path*** to receiving endpoints

Path Layer UDP Substrate BOF at IETF-96, Berlin, July 22nd 2016

- 238 Attendees at meeting for 2.5 hours
- Presentation of concept of MCP
- In-depth discussion of security-related topics
- Input to IETF decision on how to standardise

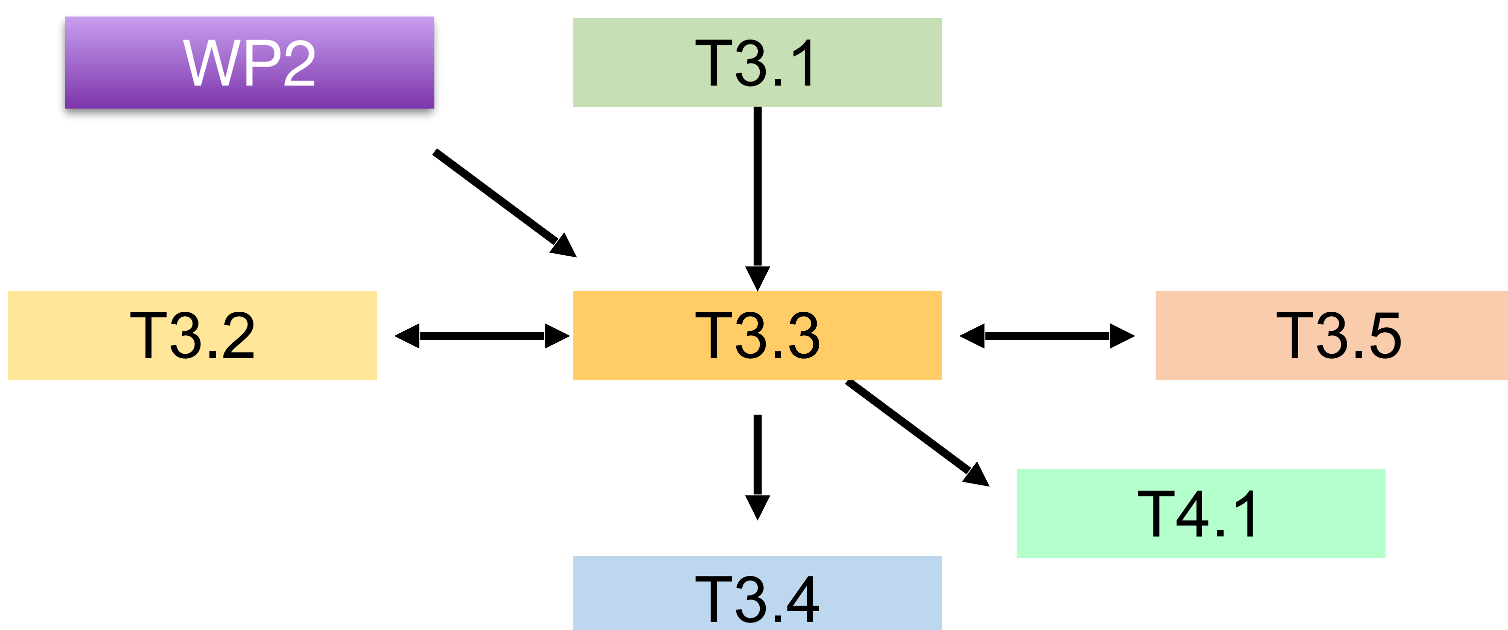
draft-trammell-spud-req
draft-kuehlewind-spud-use-cases

Architecture questions …

- Which information should be exchanged/revealed?
- How to achieve network traversal of MCP?
- What are incentives to deployment on middleboxes?
- What are incentives to deployment on endpoints?
- What if middleboxes are found to not cooperate?

T3.3: Design of a flexible cooperative transport layer
Participants: ETH, UoA, ALU

- Input from T3.1 and WP2 (and coexist with T3.2, T3.5)
- Research candidate transport mechanisms
- Propose mechanisms to complement the core MCP
- Feeds T3.4 to implement, and T4.1 to standardise



A flexible cooperative transport layer

- How quickly can MCP discover cooperating middleboxes along the path?
- What to do when middleboxes do not cooperate?
- How does the endpoint react when middleboxes mangle headers despite an expressed wish that they shouldn't?

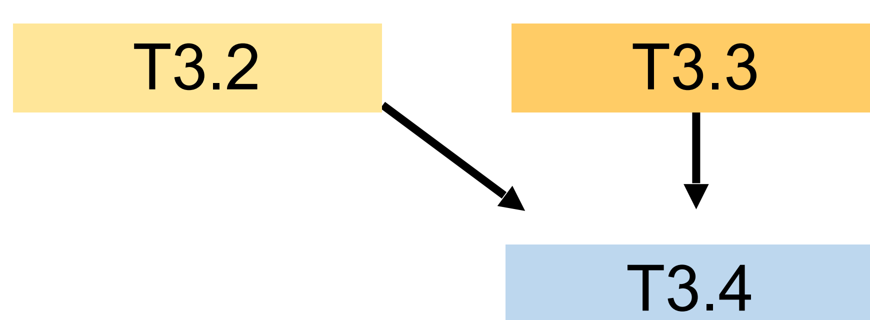
Next steps

- Initial design of MCP to exchange information between end hosts and middleboxes (target Dec 2016)
- Experience from WP2
- Complete design (mid 2017)

- D3.2 “Middlebox Cooperation Protocol Specification”
    - for M24

T3.4: Implementation and Testing

- Based on design in T3.2 and T3.3
- Cooperation with WP1 and WP2 based on measurements
- Endpoint and middlebox MCP implementation of protocols and protocol extensions
- Middlebox reference implementation for an NFV development platform.



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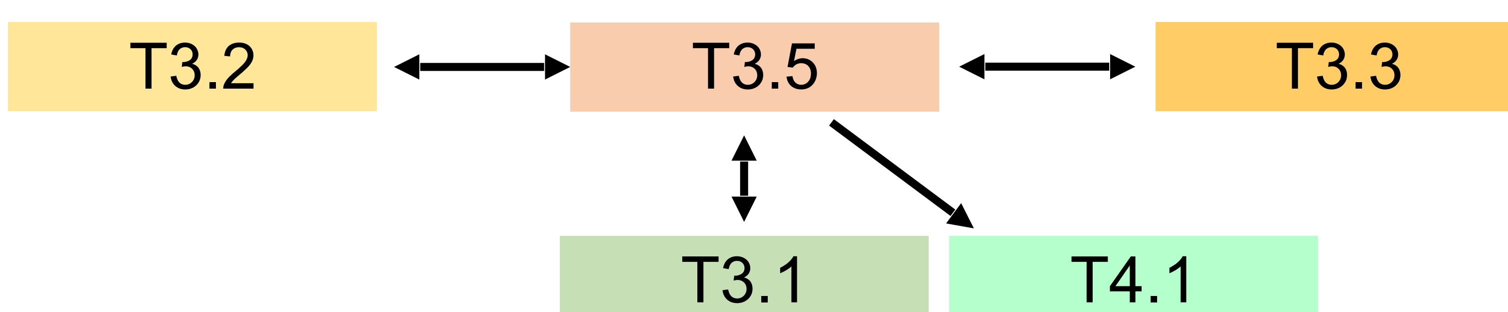
Task 3.5 Threat and Trust Analysis for Middlebox Cooperation - Started

- Coexists with T3.2, T3.3
- Developing a threat model to investigate confidentiality, integrity, authentication and trust issues
- Exploring security mechanisms and their applicability:
- Providing input to T3.1, and T4.1



Functional (and Security) Requirements Derived from the Use Cases and Principles

- **Grouping of Packets and Bidirectionally**
- **Signaling of Per-Tube Properties**
  - Path to Receiver Signaling under Sender Control
  - Receiver to Sender Feedback
  - Direct Path to Sender Signaling
  - Tube Start and End Signaling
  - Additional Per-Packet Signaling & Declarative signaling
  - Extensibility and Common Vocabulary
- **Privacy, Authentication & Integrity**
- **Encrypted Feedback**

This slide worries me.

Next steps

- A security analysis of MCP including investigation of how hard it will be to subvert
- Red team analysis of MCP and flexible transport layer (MS8)

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Dissemination

- **Publications (preparation by MAMI team)**
  - *EFGH,* ACM Hot Middlebox, London, Aug 2015.
  - *Multi-Context TLS (mcTLS),* ACM Sigcomm, London, Aug 2015.
  - B Trammell M Kuehlewind and E Gubser and J Hildebrand, *A New Transport Encapsulation for Middlebox Cooperation* IEEE Conf on Standards for Communications and Networking, Tokyo, Japan, Oct 2015.
- **Publications (relatting to WP3during MAMI project)**
  - M Kühlewin, B Trammell, *Middlebox Measurement and Cooperation,* CleanSky Conference, Heidelberg, Germany, Feb 2016.
  - M Kühlewind, B Trammell, J Hildebrand, *A Vision for Explicit Path-Cooperative Transport,* Conference on Innovations in Clouds, Internet and Networks (ICIN), Paris, France, Mar 2016.
  - M Bednarek, G Kobas, M Kühlewind, B Trammell, *Multipath bonding at Layer 3,* Applied Network Research Workshop (ANRW), ACM, Jul 2016.
  - S Liénardy, B Donnet, *Towards a Multipath TCP Aware Load Balancer,* Applied Network Research Workshop (ANRW), ACM, Jul 2016.

Standards

- **Internet Drafts**
  - draft-trammell-stackevo-explicit-coop
  - draft-trammell-spud-req
  - draft-kuehlewind-spud-use-cases
  - draft-trammell-plus-statefulness
  - draft-trammell-plus-abstract-mechanisms
  - draft-ietf-taps-transports-usage

- **Other relevant meetings**
  - MaRNEW, https://www.iab.org/activities/workshops/marnew/
  - ACCORD, https://www.ietf.org/proceedings/95/accord.html
  - PLUS BOF, IETF Berlin, https://datatracker.ietf.org/meeting/96/agenda/plus/

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Conclusion

- Task 3.1 - Concluded on time
- Task 3.2 - Started on time
- Task 3.3 - Will start month 9
- Task 3.4 - Will start month 9
- Task 3.5 - Started on time