Splitter Combiner Architecture (SCA): A Transparent PEP Architecture To Enable TCP over Multiple Paths for Single-Homed Hosts

Tacettin Ayar, Berthold Rathke, Łukasz Budzisz
and
Adam Wolisz
{ayar,rathke,budzisz,wolisz}@tkn.tu-berlin.de

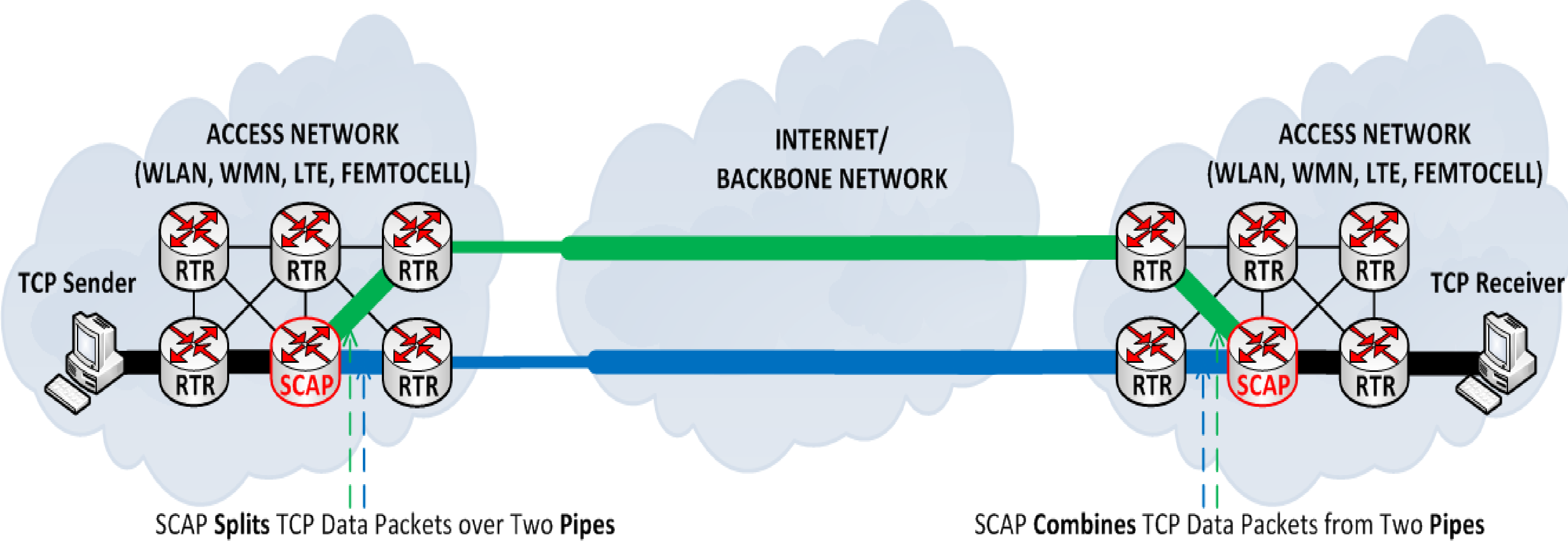
draft-ayar-transparent-sca-proxy-00

Motivation

- TCP can benefit from usage of multiple paths
- Bottleneck links are frequently observed in access networks (e.g., MEVICO Project, http://www.mevico.org)
  - WLANs, WMNs, and Femtocells may have bottleneck in the uplink
    - 1.544 Mbps T1, 1.4 Mbps ADSL2+, 10 Mbps VDSL2 lines
    - traffic demand on the uplink increases: P2P networks, video
    - splitting TCP traffic to multiple bottleneck links might be helpful
- Usage of multiple interfaces does NOT seem that evident
  - increased power consumption (e.g., TREND Project, http://www.fp7-trend.eu/)
  - customers don't want to pay higher usage costs
  - legacy devices

Basic Scenario: A pair of PEPs

- Single-homed end-systems supported by a pair of PEPs within access networks
  - SCAPs might be positioned anywhere in the network
  - SCAPs detect TCP connections and split/combine TCP traffic
  - SCAPs do not violate TCP end-to-end semantics
- Functions: bandwidth aggregation, load balancing, redundancy

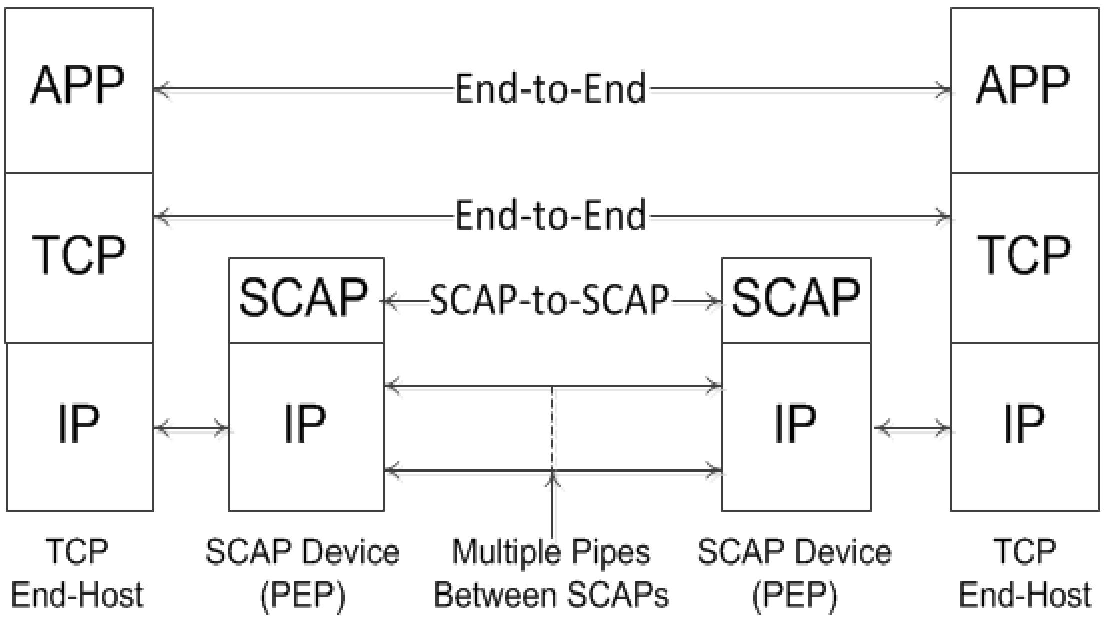


Logical Architecture

- SCAPs use multiple pipes that can be provided as:
  - Multiple interfaces of a multi-homed host
  - Routing table entries filled by a multipath routing protocol

SCAP may use the same mechanisms as MPTCP to:

- Identify the pipes (interface IP address pairs of MH Hosts/SCAP Devices)
- Pipe congestion control (MPTCP coupled congestion control)
- Keep TCP connection records

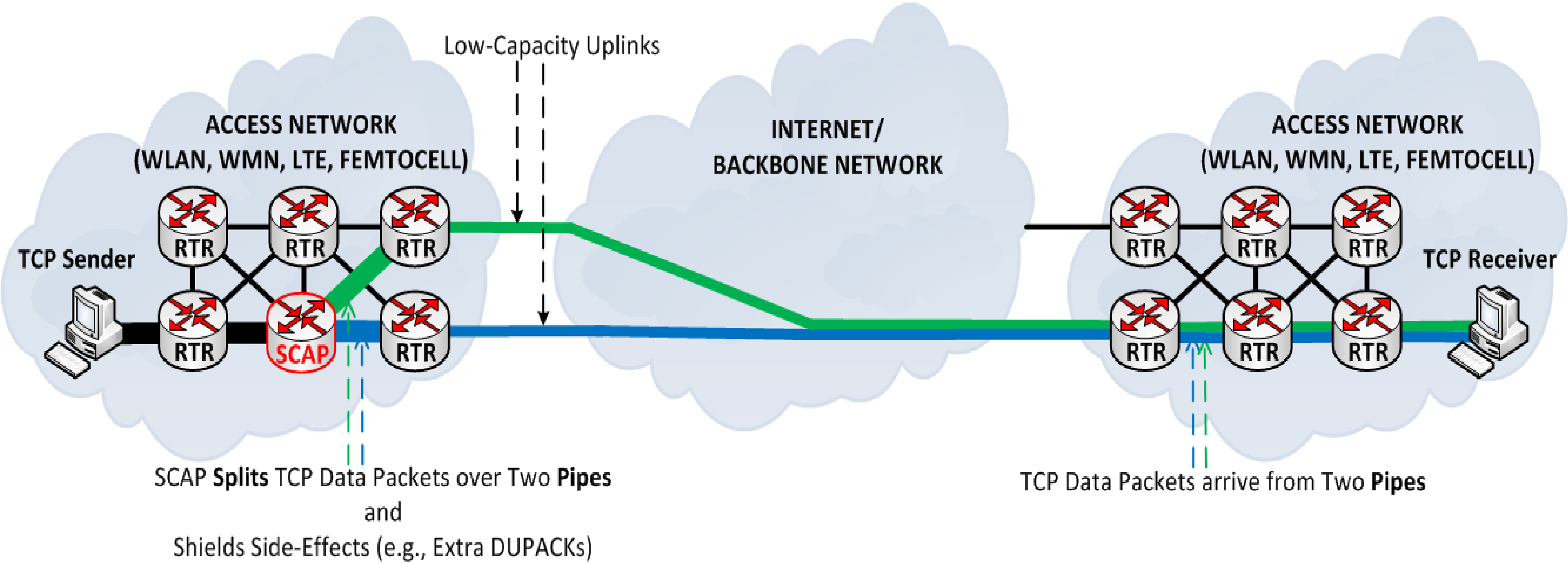


SCAP Signaling

- SCAPs use signaling to probe for other SCAPs, inform about other IP addresses, get pipe characteristics, etc.
- Example: Probing for SCAPs on the default TCP path
  - in-band: A TCP option is used to carry SCAP address information. Peer SCAP replies back with its address information
  - out-of-band: SCAPs listen on a specified port number for SCAP probe packets. First SCAP on the path sends probe packets to the specified TCP port of the network devices on the default path. If there is a listening SCAP, it replies back.
- A separate draft: signaling specification is in preparation!

Single SCAP Scenario

- A single SCAP **shapes** TCP traffic so that use of multiple paths is isolated from TCP end-points:
  - Upload performance increases (asymmetric)
  - Especially attractive during initial SCAP deployment stage
  - Note: Careful design of algorithms is necessary – *prototypes ready!*



Our Work and MPTCP Group

- Our work addresses multiple path support for TCP usage with single interface
  - End hosts may use their regular TCP!
  - SCAP may work as a single proxy as well as a pair or chain
  - An interesting complement to ongoing MPTCP work – new scenarios identified
- SCA shares mechanisms with MPTCP
  - Many MPTCP mechanisms are reusable in SCAP pairs
  - In single-SCAP scenario a constrained set of algorithms is usable
  - Supports MPTCP signaling
- SCA is complementary to multi-interface MPTCP
  - SCAPs may be used to further split MPTCP sub-flows in the network

Status and Further Work

- Prototyping a Single SCAP
  - A sample single SCAP is implemented and results are presented in

    T. Ayar, B. Rathke, Ł. Budzisz, and A. Wolisz,

    "A Splitter/Combiner Architecture for TCP over Multiple Paths,"

    TKN Technical Report Series TKN-12-001, February 2012.

    http://www.tkn.tu-berlin.de/menue/publications/tkn_technical_report_series/

- Current work: improving introduced single SCAP algorithms
- Adaptive path delay estimations
- Prevent sender from unstable RTT/RTO estimations

- Detailed specification for signaling is work-in-progress
  - Prototyping will be done based on the specification

Thanks...

SCAP-PROBE TCP Option Format

```
                        SCAP Probe Option

                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---------------+---------------+-+---------+-------------------+
|     KIND      |    LENGTH     |G|  PROTO  | FOR PROTOCOL USE  |
+---------------+---------------+-+---------+-------------------+
:                                                               :
:                      FOR PROTOCOL USE                         :
:                                                               :
:...............................................................:
```

```
                SCAP Probe Option for an MPTCP SCAP

                    1                   2                   3
0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1 2 3 4 5 6 7 8 9 0 1
+---------------+---------------+-+---------+-------+-------+-+-+
|     KIND      |    LENGTH     |G| PROTO=1 |SUBTYPE|VERSION|C|S|
+---------------+---------------+-+---------+-------+-------+-+-+
|                                                               |
|                 Option Sender's Key (64 Bits)                 |
|                                                               |
+---------------------------------------------------------------+
|                                                               |
|                Option Receiver's Key (64 Bits)                |
|                  ( If Option Length == 20 )                   |
+---------------------------------------------------------------+
```

SCAP-PROBE TCP Option Use Case

```
+----------+     +------------+               +------------+     +---------+
|   TCP    |     |    HEAD    |               |    TAIL    |     |   TCP   |
|  Sender  |     |    SCAP    |               |    SCAP    |     |Receiver |
|   (SA)   |     |    (HA)    |               | (TAB-TAF)  |     |  (RA)   |
+----------+     +------------+               +------------+     +---------+
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
         |----------------->|                             |                   |
         |   SA->RA(SYN)    |                             |                   |  T1
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
         |                  |---------------------------->|                   |
         |                  |         SA->RA(SYN)         |                   |
         |                  |                             |                   |
         |                  |---------------------------->|                   |  T2
         |                  |           HA->RA            |                   |
         |                  |     (SYN:SCAP-PROBE)        |                   |
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
         |                  |                             |------------------>|
         |                  |                             |    SA->RA(SYN)    |
         |                  |                             |                   |
         |                  |                             |------------------>|
         |                  |                             |     TAF->RA       |
         |                  |                             | (SYN:SCAP-PROBE)  |  T3
         |                  |                             |                   |
         |                  |<----------------------------|                   |
         |                  |           HA<-TAB           |                   |
         |                  |  (SYN+ACK:SCAP-PROBE)       |                   |
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
         |                  |---------------------------->|                   |
         |                  |         HA->TAB(ACK)        |                   |
         |                  |                             |<------------------|
         |                  |                             | SA<-RA(SYN+ACK)   |
         |                  |                             |                   |  T4
         |                  |                             |<------------------|
         |                  |                             | TAF<-RA(SYN+ACK)  |
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
         |                  |<----------------------------|                   |
         |                  |       SA<-RA(SYN+ACK)       |                   |
         |                  |                             |                   |
         |                  |                             |------------------>|
         |                  |                             |   TAF->RA(ACK)    |  T5
         |                  |                             |                   |
         |                  |                             |------------------>|
         |                  |                             |   TAF->RA(RST)    |
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
         |<-----------------|                             |                   |
         | SA<-RA(SYN+ACK)  |                             |                   |  T6
 . . . . | . . . . . . . . . | . . . . . . . . . . . . . | . . . . . . . . . | . . .
```

Single SCAP – Initial Evaluation