Towards the Future Internet

An Overview of Challenges and Solutions in Research and Standardization

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How will the Internet look in 2020?

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- Revolutionary approaches
  - Clean slate approaches
- Evolutionary approaches
  - Extending the existing Internet
  - Slow migration
- Goal of this talk: an outline of the evolutionary track
  - Standardization activities of the IETF
  - Our related research at the University of Duisburg-Essen

Migration to IP Version 6

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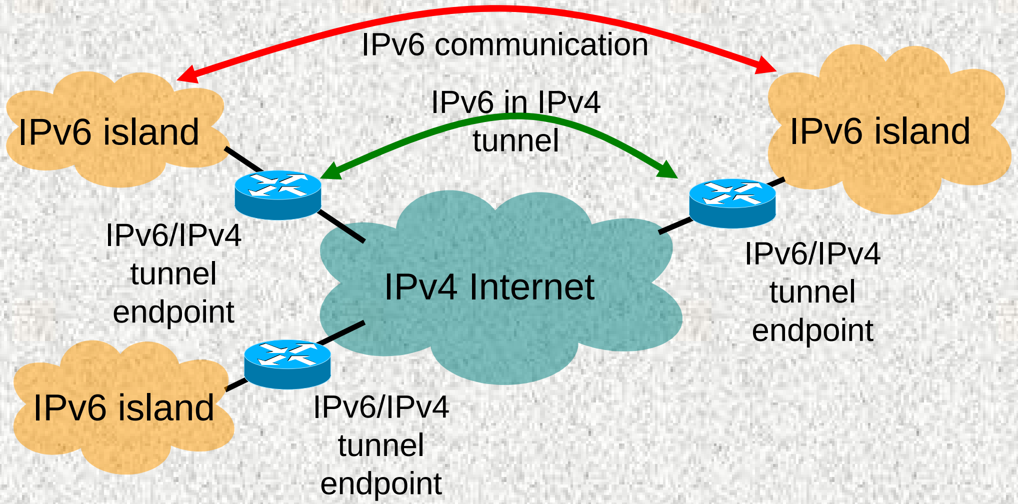

In the (not so far) future:
- IPv4 over IPv6 tunnels
- IPv4 islands

- Multi-homed sites:
  - IPv4 and IPv6 in parallel
  - Multiple IPv6 providers (e.g. provider and tunnel broker)
- Challenge:
  - Copying with this redundancy
  - TCP establishes connection between two IP addresses => one path
  - Solution: SCTP

From TCP to SCTP

- SCTP – Stream Control Transmission Protocol
- “Next Generation of TCP”
- Main motivation: telephone signalling transport (SS7) over IP

- **1998** Signalling Transport (SIGTRAN) Working Group
- Improvements and extensions of the SCTP drafts
- First prototype implementations, e.g. *SCTPLIB*
- Interoperability tests

IETF

Almost 10 years

- October 2000: RFC 2960 (official SCTP standard)
- September 2002: RFC 3309 (change of checksum algorithm)
- April 2007: RFC 4460 (corrections and clarifications)
- **September 2007**: **RFC 4960** (updated official SCTP standard)

Multi-Homing

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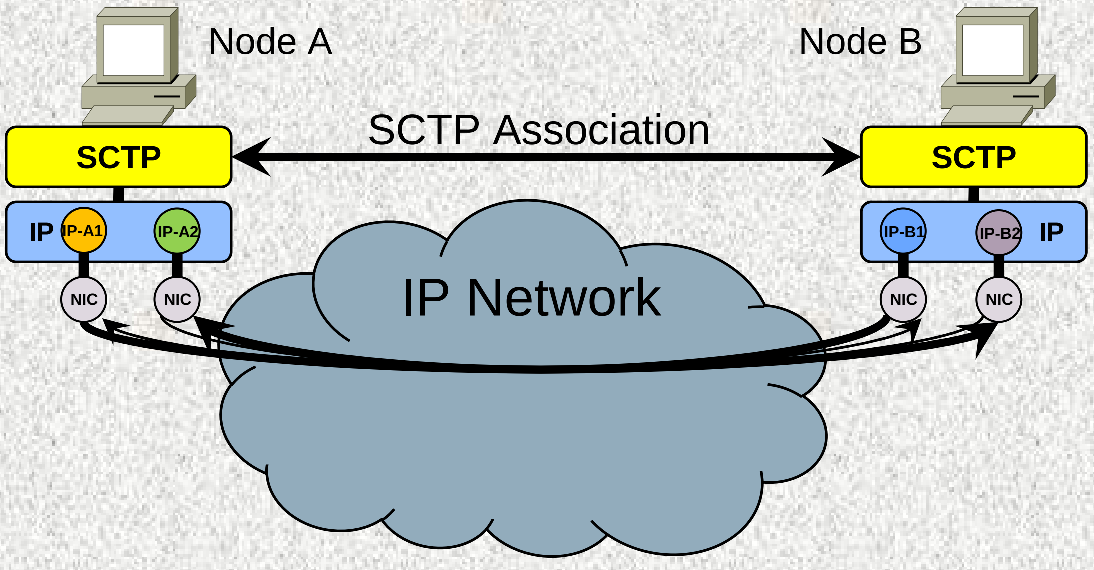
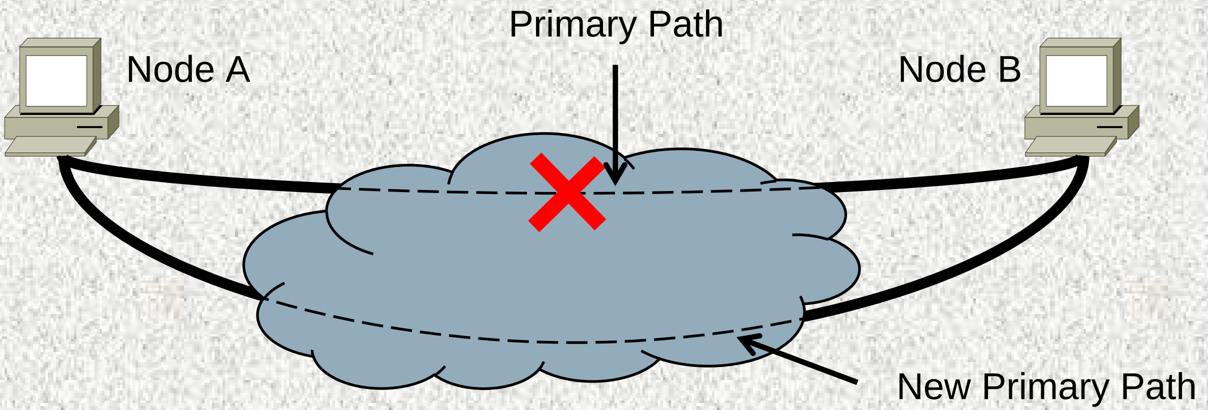


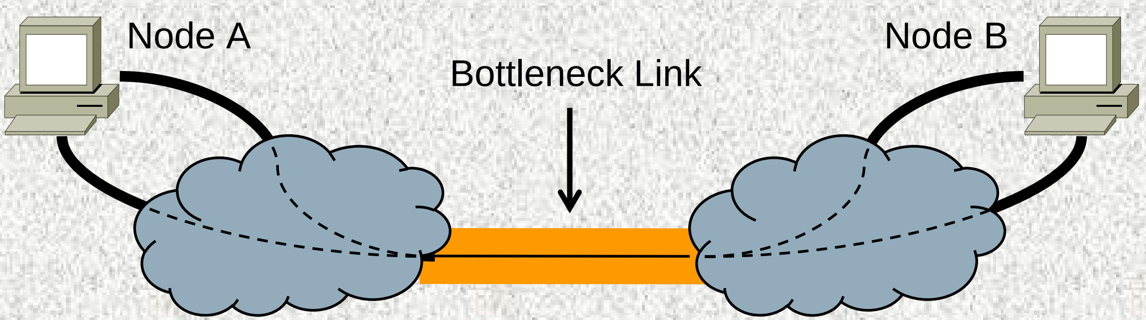
- **Association** = connection between two endpoints
- **Path** defines <u>unidirectional</u> relation to one of remote peer's addresses
- **Primary path** = selected path used for data transmission
- Break of primary path => switching to another path
  - Alternative path is also used for retransmissions

Changing the Primary Path



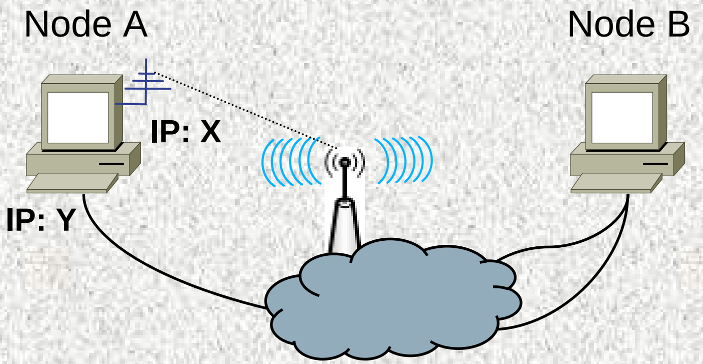
- Upon failure of the primary path …
  - … SCTP selects another path
- Upper layer has to do nothing …
  - … but can be notified about the path change (by option)
- Upper layer can explicitly request a change of the primary path:
  - Locally
  - From the remote node to itself (i.e. for the reverse direction)
- Current research topic: which path to choose?

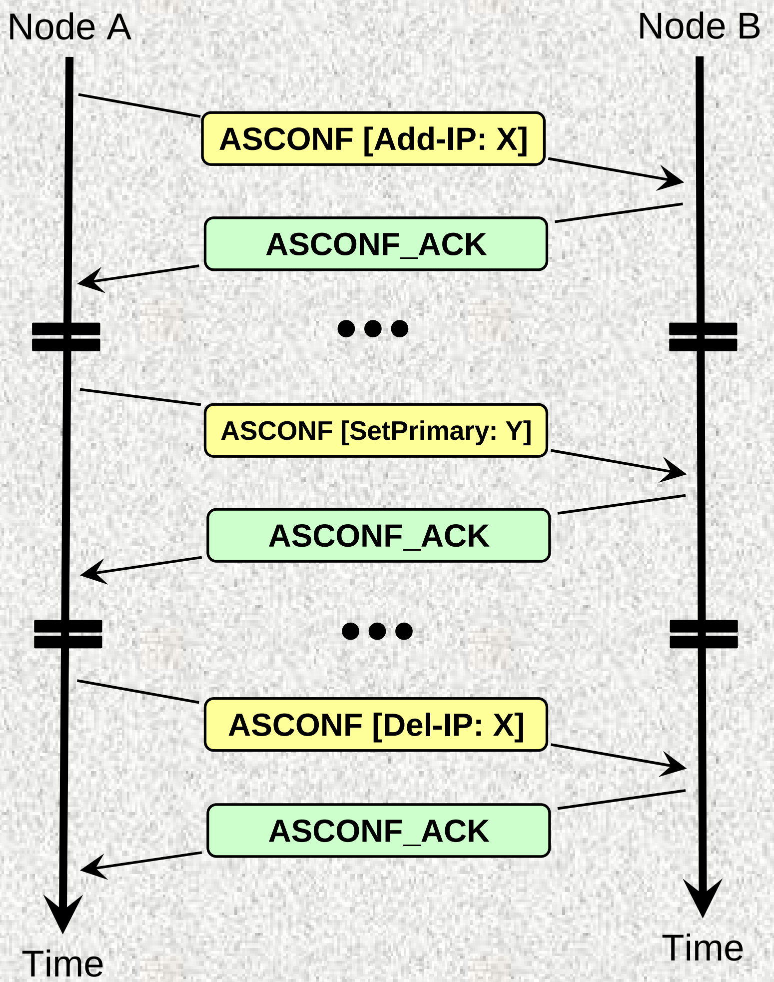
Why is there only one Primary Path?



- Example:
  - Two paths between nodes A and B
  - Both paths share the same bottleneck link
  - If both paths would be used for data transmission:
    - Behaviour would be similar to two TCP flows
    - In case of congestion: unfair to other TCP/SCTP flows running over the same bottleneck!
- Network topology is unknown – there may be non-disjoint paths
- Current research topic: Concurrent Multipath Transfer (CMT)

Dynamic Address Reconfiguration ("Add-IP")





- Dynamic Address Reconfiguration
- Defined in RFC 5061
- Application:
  - Adding new IP addresses (Add-IP):
    - Example: reachable W-LAN
  - Can be combined with explicit Primary Path setting
  - Removing IP addresses (Del-IP):
    - Example: unreachable W-LAN

Copying with IPv6 Multi-Homing Challenges

- Simple case #1: **provider change**
  - Add addresses with advertised new prefix
  - Remove addresses with old prefix
- Simple case #2: **adding redundancy**
  - Add addresses with prefix of another provider
  - Connections to multiple providers, for redundancy
- Simple case #3: **mobility**
  - Adding W-LAN when reachable …
  - … while also being connected over Ethernet
- Extreme case: seamless **migration** from **IPv4 to IPv6**
  - Possible without interrupting associations
  - Dual-stack endpoints required, of course
- Current research topics:
  - Use which path when? Handover optimizations …

The Need for Availability

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- SCTP provides features for many network challenges …
- … but cannot protect against a server failure
- Classic Internet applications:
  - Mail, FTP, HTTP, …
  - In case of server failure: service unavailable, until repaired
- **New applications**:
  - E-commerce, e-health, telephony over Internet, …
  - Even short service **outages are critical**, e.g.:
    - For e-shops, customers simply go to competitor (and never come back again)
    - Handling emergency calls with Internet telephony
- Required:
  - **Service availability** by **component redundancy**

Reliable Server Pooling (RSerPool)

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- Realizing service availability:
  - Formerly, each critical application realized its own mechanisms
- Observation:
  - Large parts of these implementations essentially do the same …
  - … and developers reinvent the wheel again and again ☹
- The IETF's solution:
  - "A unified, application-independent and lightweight framework for pool and session management"

Reliable Server Pooling – RSerPool

About 9 years

- **1999** Foundation of the IETF RSerPool WG
- **September 2008** Publication of the core protocols as RFCs

RSerPool Overview (RFC 5351)

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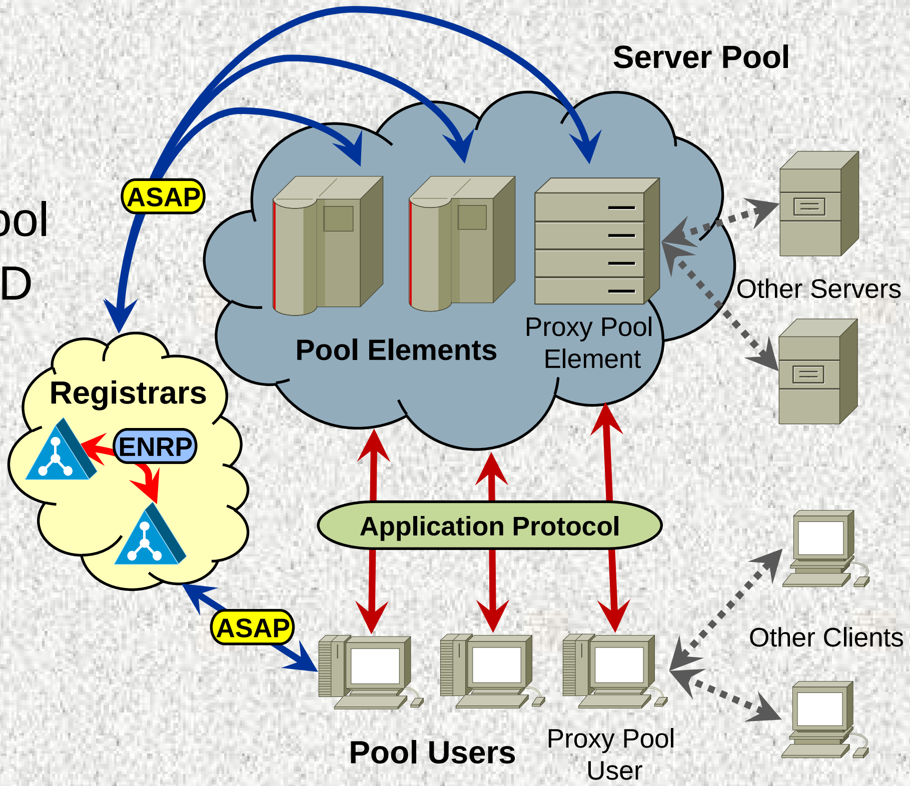
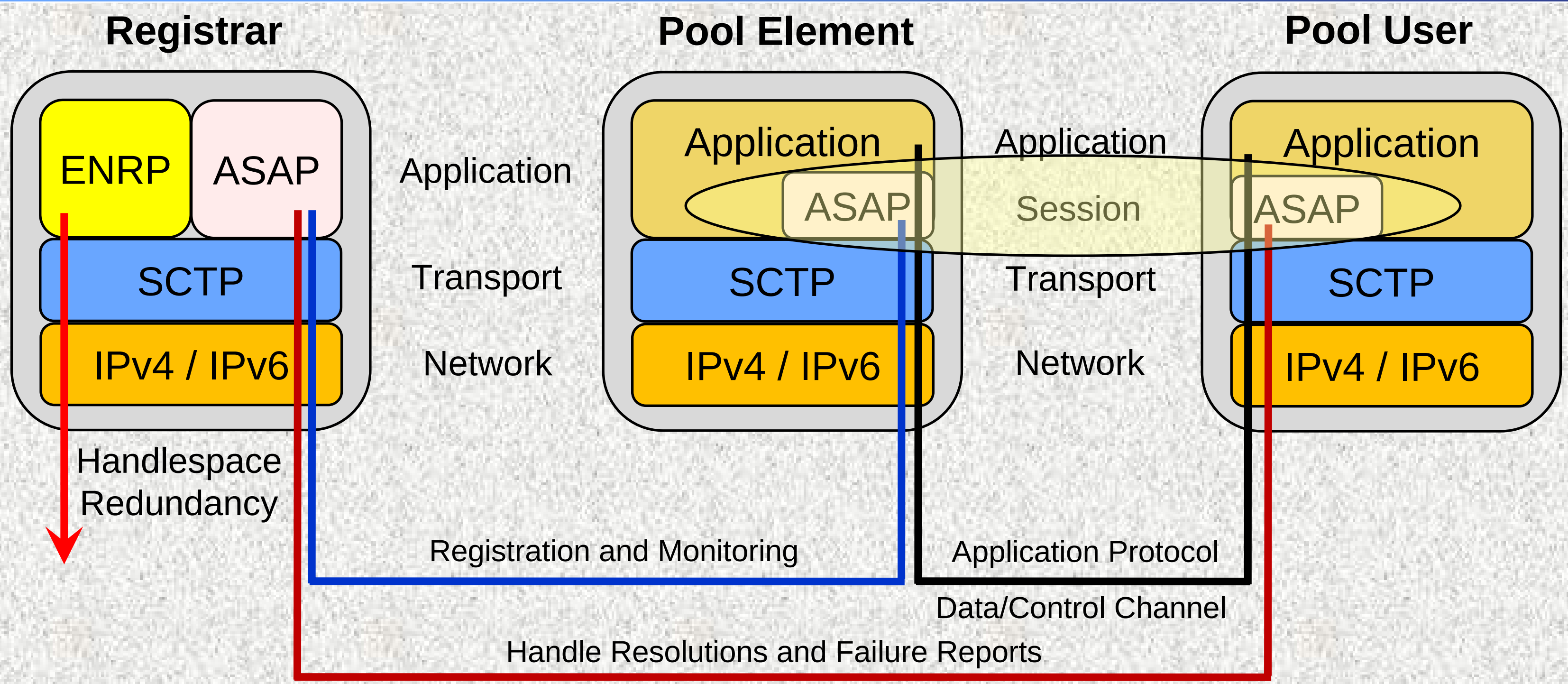
- Terminology:
  - **Pool Element (PE)**: Server
  - Pool: Set of PEs
  - PE ID: ID of PE in pool
  - Pool Handle: Unique pool ID
  - Handlespace: Set of pools
  - Pool **Registrar (PR)** Management
  - **Pool User (PU)**: Client
  - Support for existing applications:
    - Proxy Pool User (PPU)
    - Proxy Pool Element (PPE)



- ASAP = Aggregate Server Access Protocol (RFC 5352/RFC 5356)
- ENRP = Endpoint Handlespace Redundancy Protocol (RFC 5353)

RSerPool Protocol Stack



- Aggregate Server Access Protocol (ASAP)
  - PR ⇔ PE: registration, deregistration and monitoring by Home-PR (PR-H)
  - PR ⇔ PU: server selection, failure reports
  - PU ⇔ PE: session management
- Endpoint Handlespace Redundancy Protocol (ENRP)
  - PR ⇔ PR: handlespace synchronisation

Current RSerPool Research Topics

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- Applications scenarios:
  - SS7 telephone signalling over IP, also VoIP with SIP
  - IP Flow Information Export (IPFIX)
  - Video on demand services
  - E-commerce
  - Battlefield networks
  - **Load distribution and balancing**
- Fine-tuning of parameters for certain scenarios:
  - Further reduction of management overhead (CPU, memory)
  - High-latency setups
  - Disaster scenarios
- Security:
  - Robustness against Denial of Service (DoS) attacks
  - Attack countermeasures

Conclusion: The Internet in 2020

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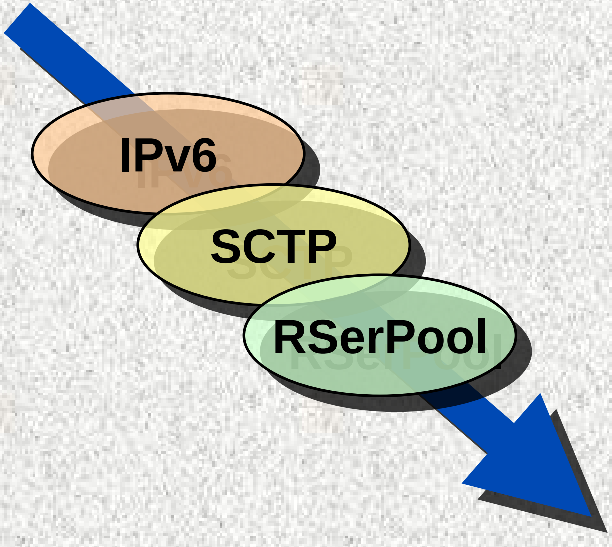
- Internet development is slow and more evolutionary than revolutionary …
- Deployment today:
  - IPv6 support widespread
    - All relevant operating systems
    - Some providers
  - SCTP
    - Supported by major operating systems
  - RSerPool:
    - Start of deployment
- Deployment in 2020:
  - IPv6: absolutely sure
  - SCTP: quite sure
  - RSerPool: probably
- Beyond 2020:
  - Evolution to approaches which are considered revolutionary today?



Thank You for Your Attention!

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Questions?

Visit our Project Homepage:
http://www.iem.uni-due.de/dreibholz/rserpool/