Multipath Networking at Transport Layer

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Background

- New generation devices with multiple interfaces: e.g. iPhone, Android, …
  - Various technologies e.g. WiMAX, WiFi, 3G, …
- User has various outgoing interfaces with various technologies
- How can we take benefit of this multiple connectivity in a Web2.0 and HTML5 context?

Our Proposal

- Idea: using multipath protocol
  - MPTCP (Multipath TCP)
  - CMT-SCTP (Concurrent Multipath SCTP)
  - And many others in many layers
- Extending capabilities of MP protocols with:
  - Path selection
  - Dynamic CC selection
  - Selectable reliability
    - Switch between various reliability flavours and levels
      - ARQ, FEC, selective retransmission, …
- Objective: enhancing Quality of Experience (QoE)

What are the metrics?

- How to make the best use of availability of several interfaces at a time to improve user's QoE in terms of:
  - Good-put (application throughput)
  - Delivery delay
  - Delivery ratio
- Our preferred protocol: "CMT-SCTP"
  - Provides data simultaneous data transmission over multiple paths
  - Partial Reliable transmission
  - Message oriented transmission

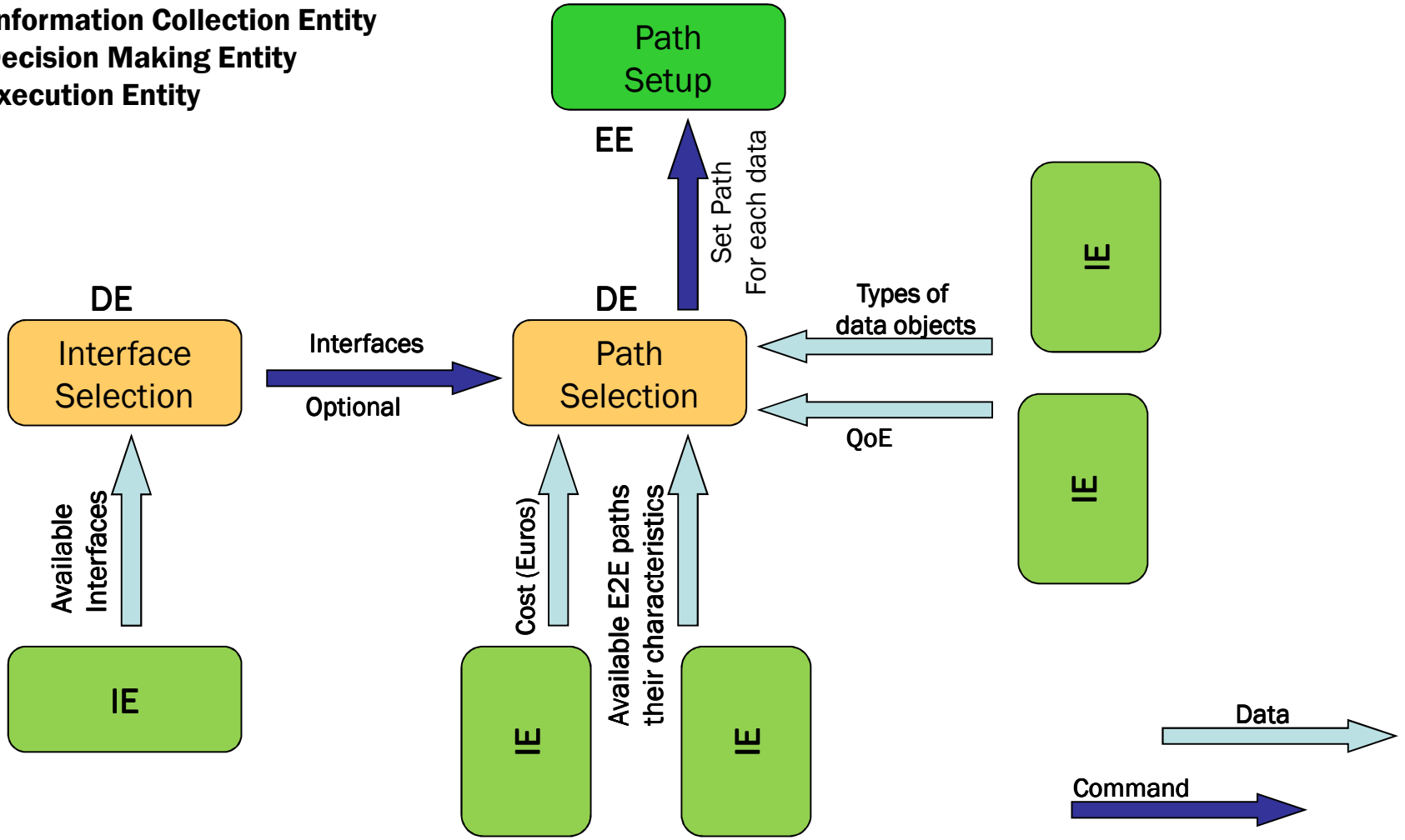
Big Picture

- We propose a combination of:
  - Information collection element
    - From the network (e.g. RTT, loss …)
    - From the user (e.g. data type, desired reliability, CC …)
  - Decision Making element
  - Execution element

- Decision Making could be based on:
  - Path characteristics
  - Object type
  - Congestion Control of preference
  - Desired reliability
  - Price user is willing to pay
  - Battery consumption
  - Security

Block Representation of the Problem

- **IE = Information Collection Entity**
- **DE = Decision Making Entity**
- **EE = Execution Entity**

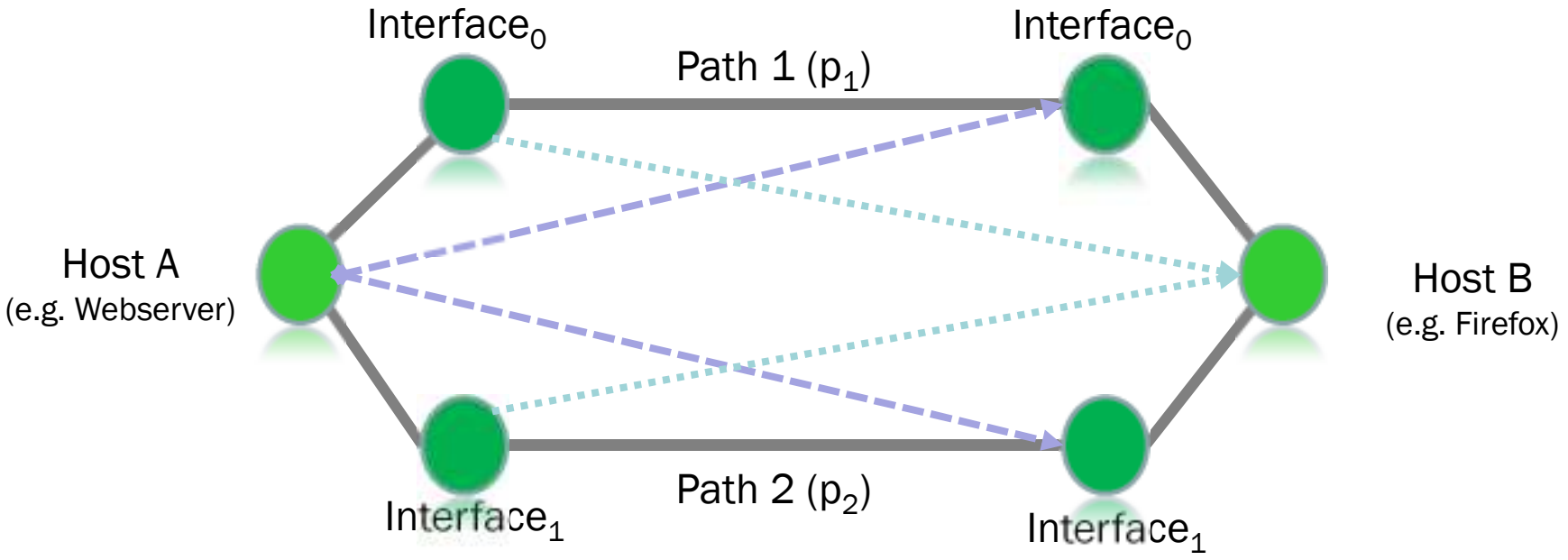


Source: SAIL Project Meeting, Feb, 2011

What do we need?

- Model of packet scheduling mechanism present inside MP Protocols (SCTP for instance)
  - Objective: to model packets scheduling at the sender side and expectation of the windows
- How to assess the correct parameters?
- Simulations expected to infer such models
  - To cross-check models and results

Simple Multipath Scenario



- If either of host A or B is multi-homed, they can benefit from multipath data delivery.

A Little on Jargons

- About SCTP features:
  - TCP is byte-stream oriented, while SCTP is message oriented
  - TCP has head-of-line-blocking, SCTP does not
  - SCTP provides multi-homing, TCP does not

- Path (physical)
- Flow, Sub-flow (logical)
- Stream (logical)

Byte-stream vs. Message Oriented Data

Send Data - Write()

Receive Data - Read()

Byte-stream Transmission (TCP)

- Data remains sequential but boundaries may not be maintained.

Message Based Transmission (SCTP, UDP)

- Data remains sequential and strict boundaries are maintained.

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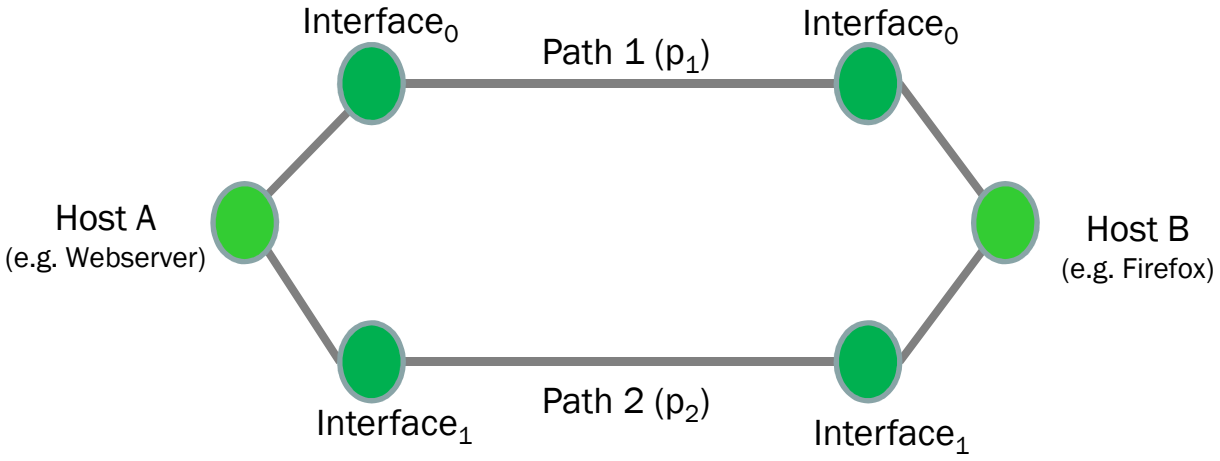
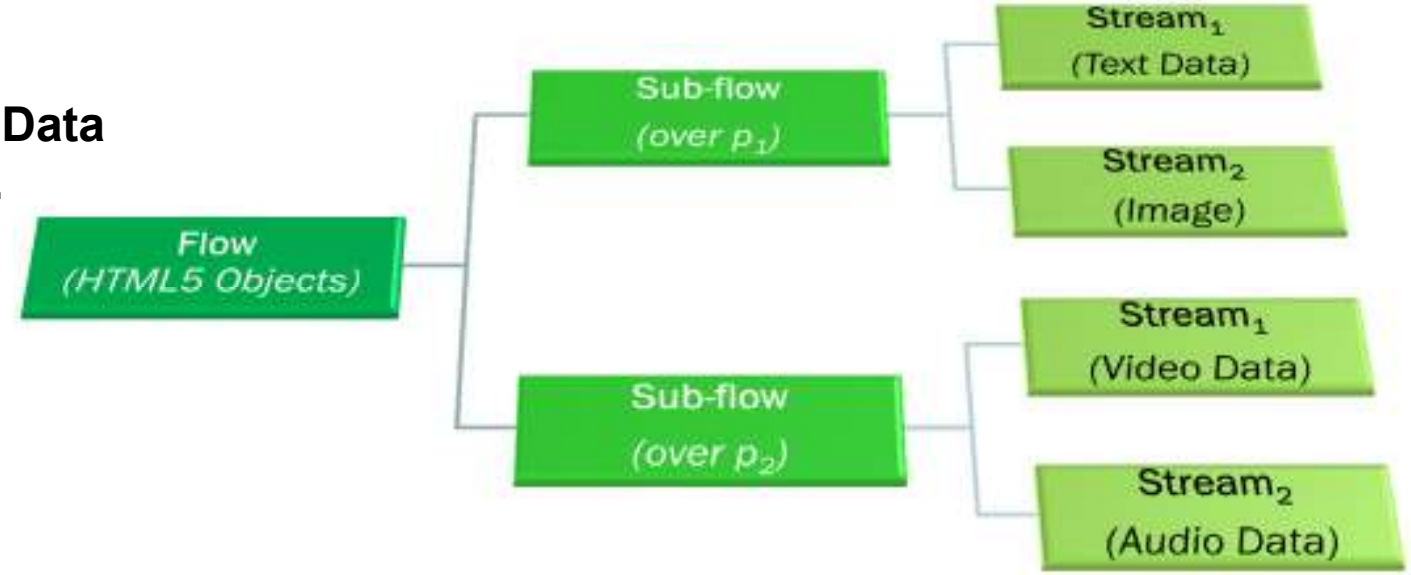
Flow, Sub-flows and Streams in Multipath



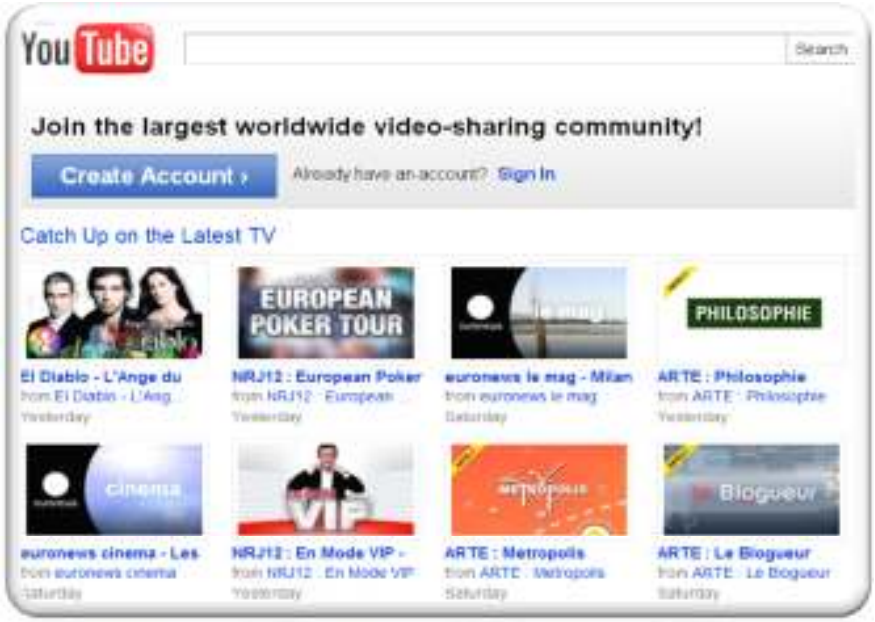
- **Physical Representation of Data Transmission**

- **Logical Representation of Data Transmission.**



On the benefit of multi-stream/flow

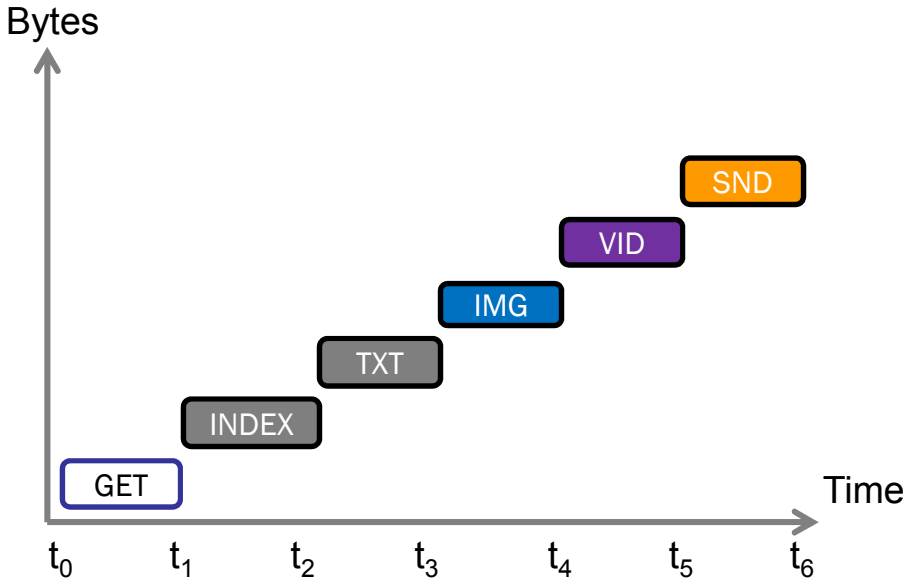
Traditional HTML5 Page



Most common HTML5 contents are:

1. Text
2. Image
3. Audio
4. Video

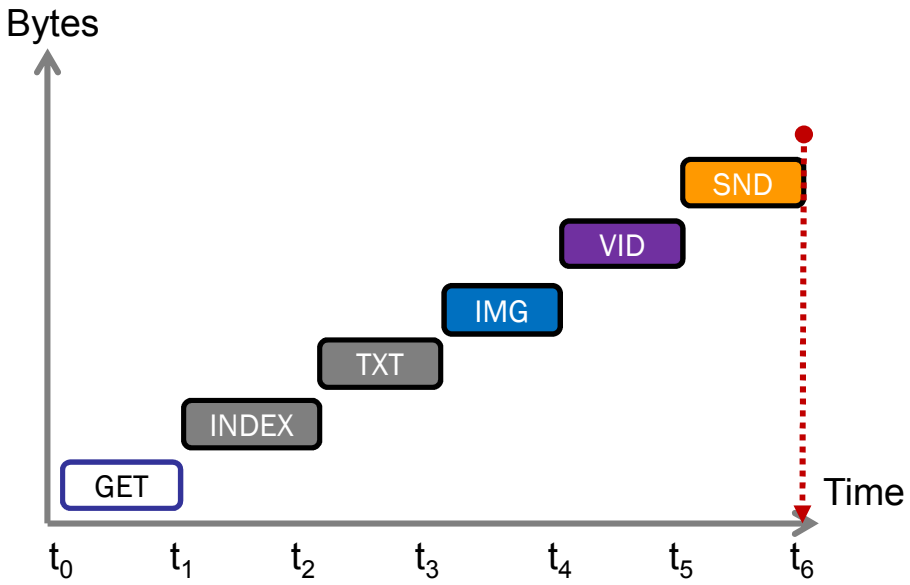
Traditional HTML5 Data Delivery



Individual text, image, video and audio data are transmitted in individual packets using a single transmission path at a time.

Proposed Multipath Data Transmission Scheme

Traditional HTML5 Data Delivery



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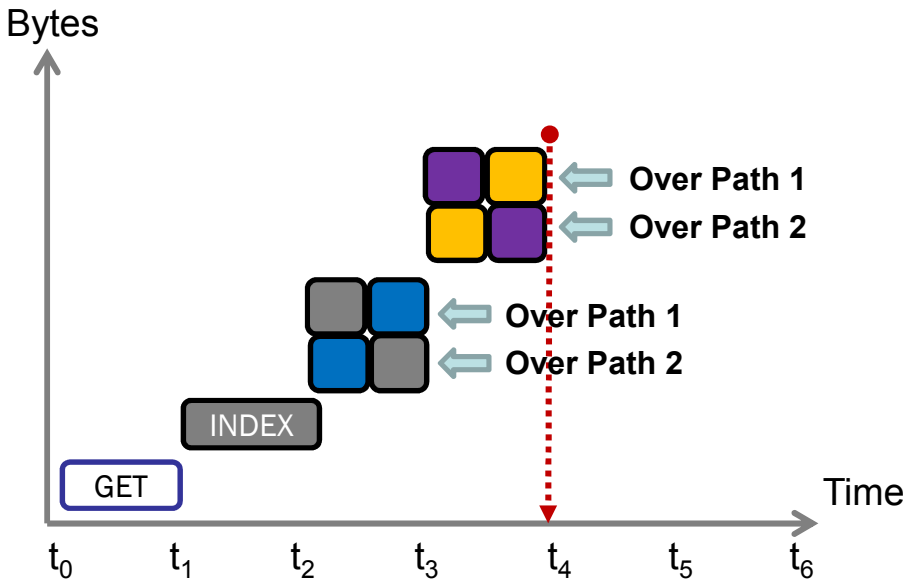
Proposed Multipath HTML5 Data Delivery



Multiplexed text, image, video and audio data are transmitted within single packets using a multiple transmission paths at a time.

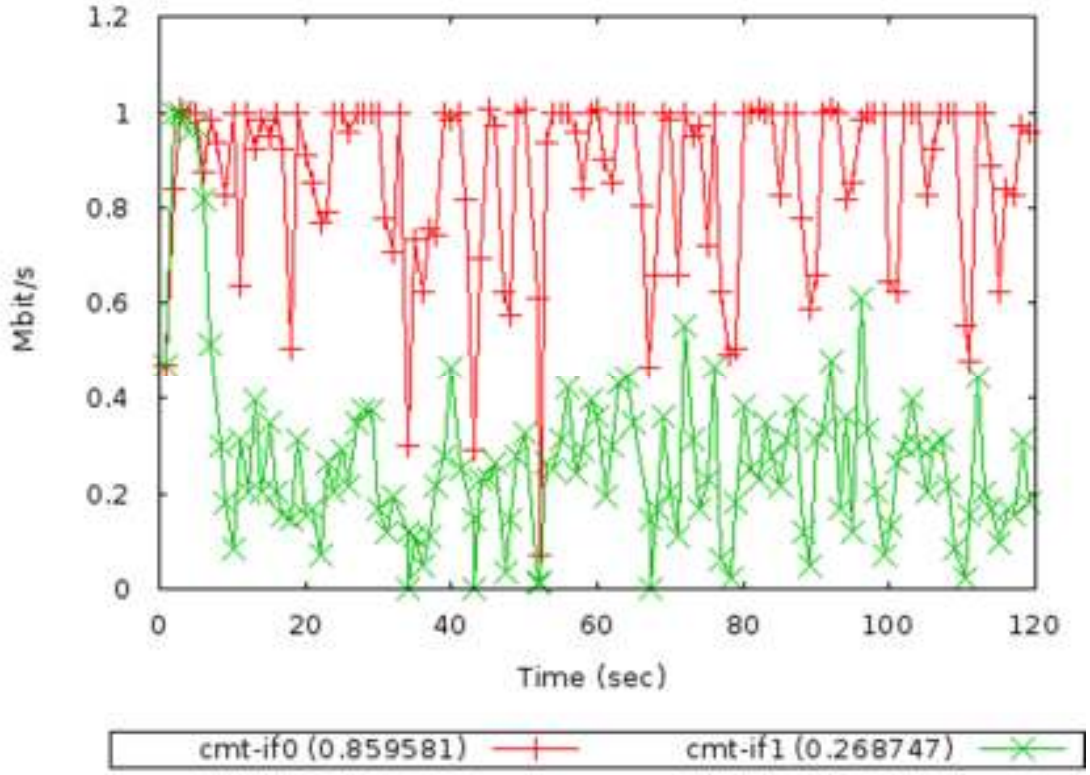
Next Step

- Proof of concept with illustrative simulations
- Measurements scenario (TBD)
- Analytical models of the data scheduling between sender's windows
  - Finite state machine as an entry point for Model Checking
  - State diagrams of data exchange
    - Allows to use Formal Method (Advanced UML) in order to obtain a "proof of protocol" and to better model
  - Use of Dynamic Weighted Fair Queuing (WFQ) (based on RTT, loss)
- Implementation in Linux/FreeBSD

Current Progress

- NS-2 simulations of MP protocols
- Preliminary measurements

Figure: NS-2 simulation of reliable and ordered delivery of a single object over 2 paths using CMT-SCTP.



Thanks for Your Attention

Any Questions?