Karlsruher Institut für Technologie

# Realistic Underlays for Overlay Simulation

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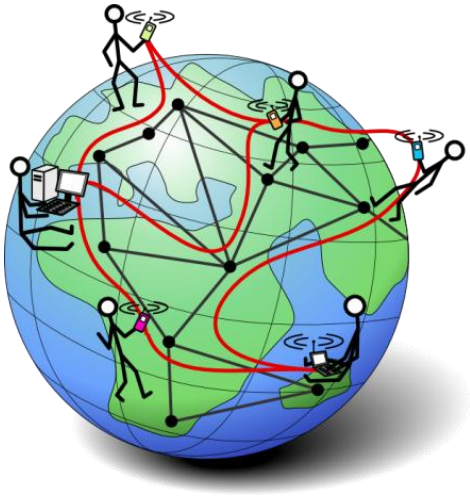
# Motivation

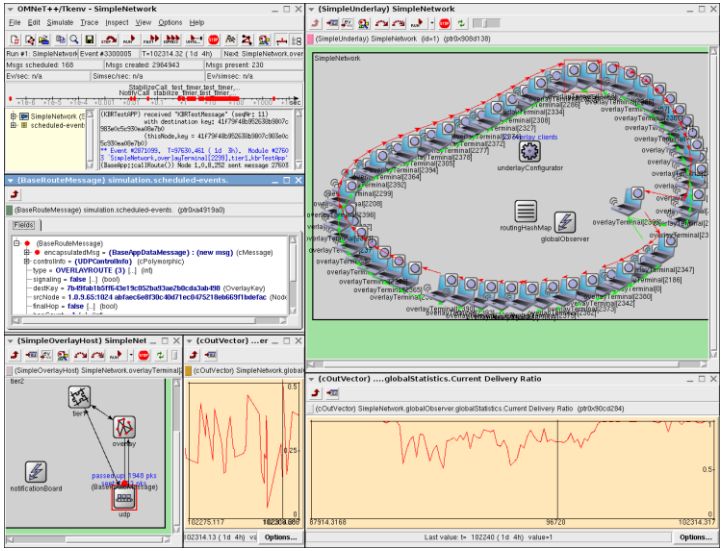
- P2P networks enable the flexible and scalable deployment of novel services
  - Popular examples: BitTorrent, Skype, Amazon´s Dynamo
- But: Behaviour of P2P networks is often complex and hard to predict
- Simulation helps to determine e.g. suitable protocol parameters
  - OverSim is a popular tool to simulate all kind of P2P networks
- P2P networks are usually overlay networks
  - Logical network on top of existing underlay network
  - Newer P2P protocols try to adapt the overlay topology to the underlay
    - Application Layer Multicast
    - Low latency DHTs
    - IETF ALTO Traffic Optimization
    - …



→ To get accurate results we need realistic underlay models for OverSim!

# OverSim: The Overlay Framework

Our overlay framework OverSim based on OMNeT++ provides:



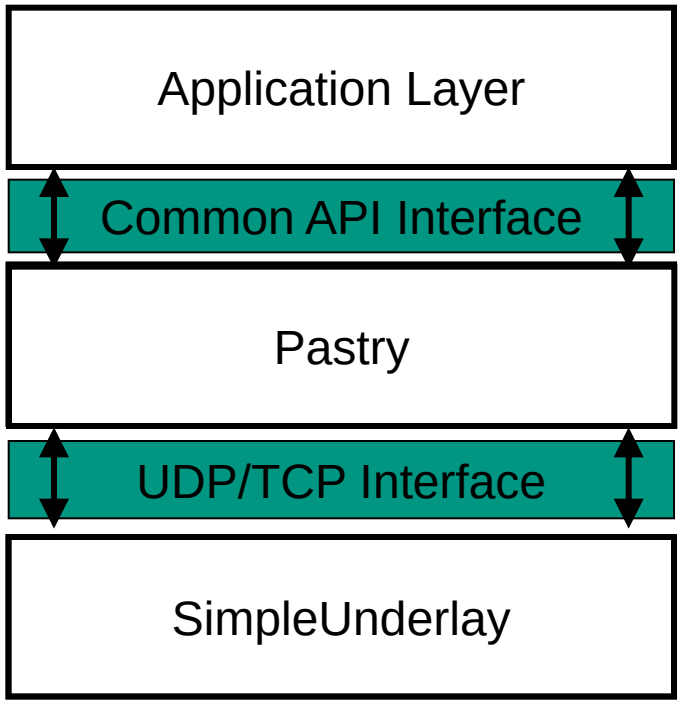
- Support for simulation and real world applications
- Rapid development of new overlay protocols
- Scalability (>100.000 nodes) and flexibility due to a modular design
- Several state of the art overlay protocols:
  - Chord, Koorde, Pastry, Bamboo, Kademlia, Broose, Gia, VAST, QuON, Scribe, SimMUD, NICE
- Several overlay applications:
  - Generic DHT, i3, P2PNS, Gaming Application

OverSim
The Overlay Simulation Framework

# Modular architecture

- Layered architecture
  - Underlying network
  - Overlay layer
  - Application layer
- Consistent interfaces between layers
  - UDP/TCP between network and overlay
  - Common API between KBR overlay and application

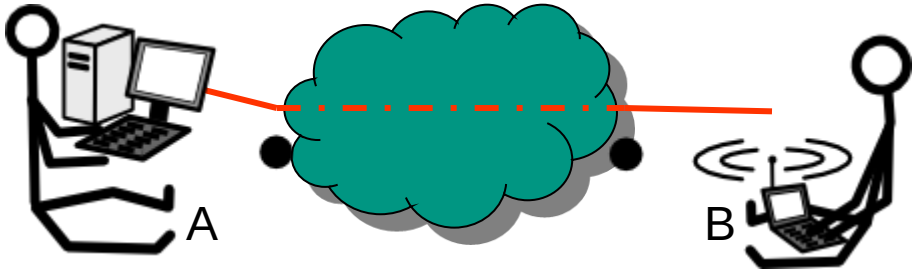
  → Exchange of one component is transparent to all other components



# Classical OverSim underlay models

- SimpleUnderlay
  - Low computational overhead
  - Coordinate-based delays calculated from CAIDA/Skitter measurements
  - Logical access network

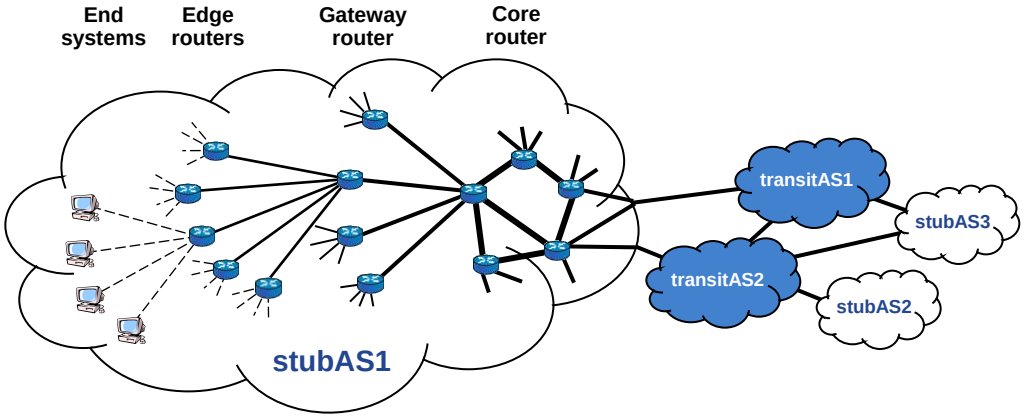
$$d_e = d_A + \frac{l_p}{b_A} + c \cdot \| A - B \|_2 + d_B + \frac{l_p}{b_B}$$




- InetUnderlay
  - Based on the INET framework
  - Complete IP stack is modeled
  - Backbone simulation
  - Extendable by INET framework models, e.g 802.11

→ Lacks support for a proper topology generator for realistic Internet topologies!

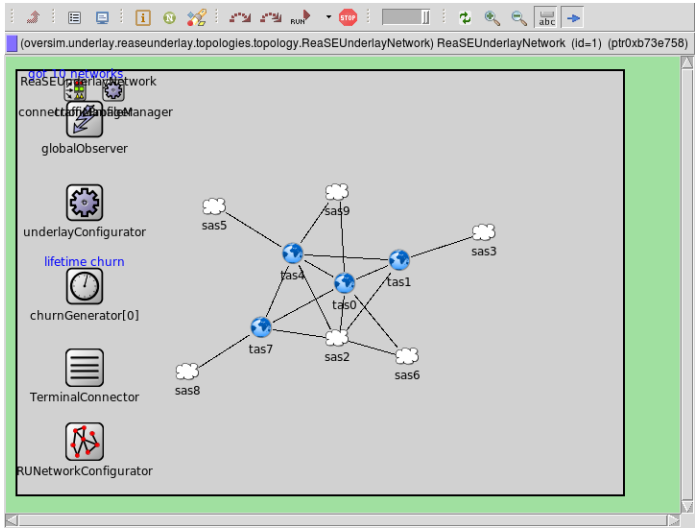
# ReaSE topology generator

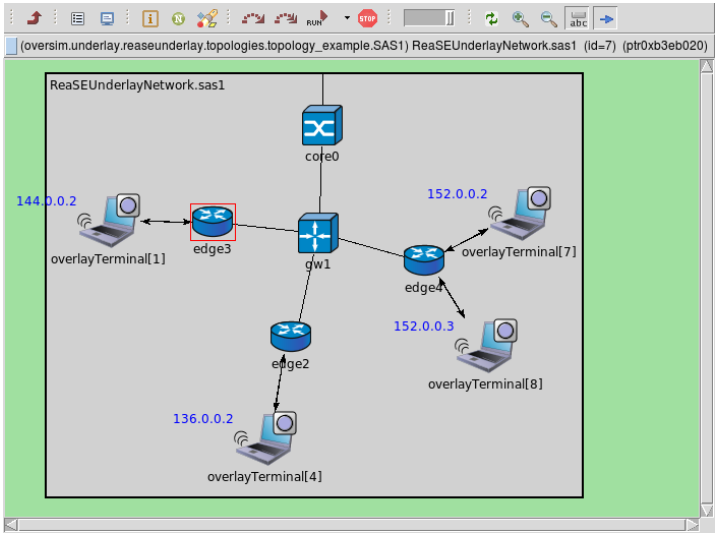



- Internet-like topologies
  - Two hierarchy levels: AS level and router level
    - Differentiates between Transit AS and Stub AS
    - Additional hierarchy in the router level topology
      - Market demands like link costs result in hierarchical router topology
- Modelling of realistic background traffic
  - Reasonable mix of different kinds of traffic
    - ➔ Traffic profiles define flow behavior
- Related Work
  - Only state of the art generation topology generators relevant: Degree-based graph model
    - TIERS, GT-ITM, BRITE are all based on obsolete models
  - Focus only on AS level topology
  - Often separate tools for topology generation and background traffic

# Integration of ReaSE in OverSim

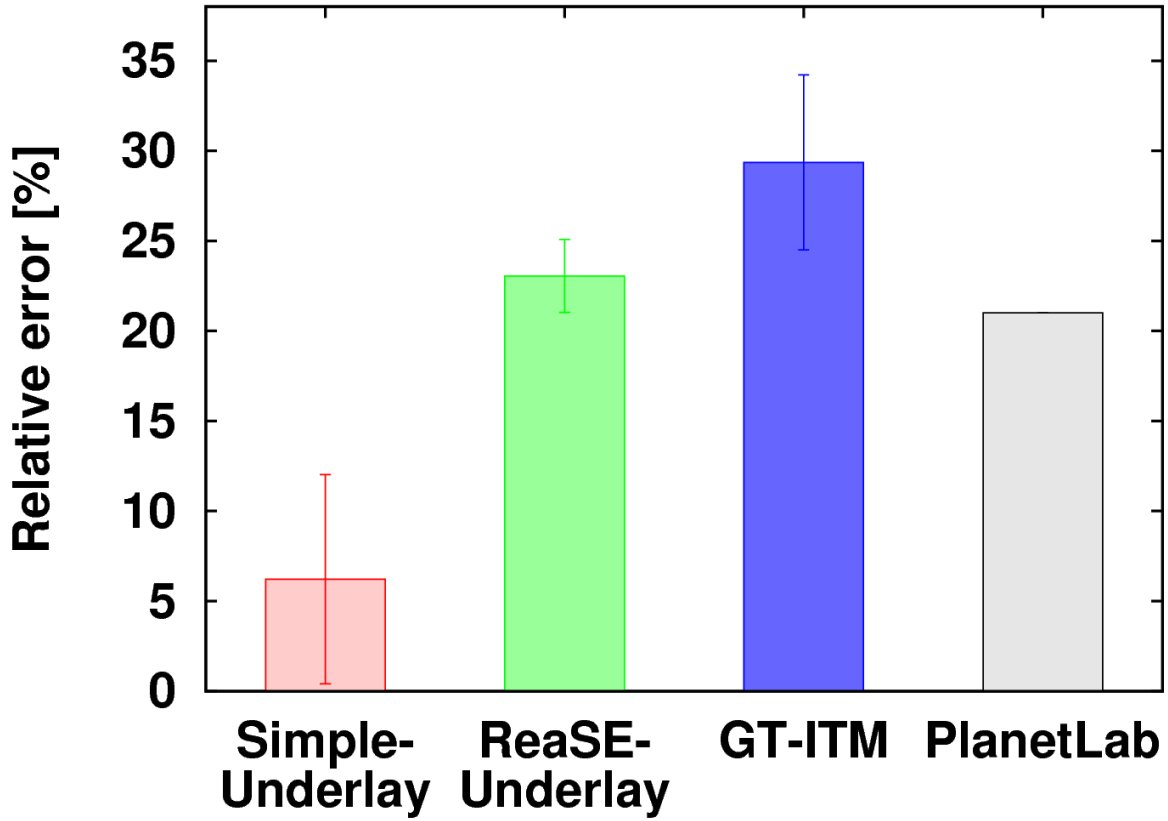
- Several modifications to ReaSE to generate OverSim compatible NED file
- In contrast to InetUnderlay the network contains only AS modules (so no routers and no overlay terminals)
- AS modules contain core routers, edge routers and overlay terminals
- Global TerminalConnector and RUNNetworkConfigurator modules parse the underlay topology, assign IP addresses and connect overlay terminals
- Optional ConnectionManager is used to generate background traffic



# A quick look at simulation results…

- Network coordinate system Vivaldi with different underlay models




ReaSEUnderlay shows closest relative error results to real network measurements in PlanetLab

# What is the best underlay model?

- SimpleUnderlay
  - ✚ Very scalable (up to 100.000 nodes)
  - ✚ Typical Internet end-to-end delays
  - ▬ Models only end systems (no overlay nodes in the network core)
- InetUnderlay
  - ✚ Models queuing effects in intermediate routers
  - ✚ Access to all models of the INET framework (e.g. 802.11)
  - ▬ Not possible to model the whole internet backbone on router level
  - ▬ Generates only basic random topologies
- ReaSEUnderlay
  - ✚ All benefits of the InetUnderlay
  - ✚ Realistic topologies based on real-world Internet observations
  - ▬ Also not possible to model the whole internet backbone on router level

# Conclusion

- OverSim is a scalable and flexible P2P simulation framework
- ReaSE is a tool to generate realistic underlay topologies and background traffic based on Internet observations
- The integration of ReaSE in OverSim leads to a new powerful underlay model, which is especially useful for the evaluation of
  - Application Layer Multicast (ALM)
  - Network coordinate systems (e.g. Vivaldi)
  - Traffic Optimization (e.g. IETF ALTO)
- Disadvantage is the increased resource consumption…

…choose your underlay model wisely!

OverSim
The Overlay Simulation Framework

Available on
http://www.oversim.org/