KauNet: A Versatile and Flexible Emulation System

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KauNet: Deterministic Network Emulation

Evaluating Network Systems

- *Network evaluations can be done in several ways, e.g. by mathematical modeling, network simulation, network emulation, and live experiments*
- ***Every approach has its drawbacks***
  - *Models and simulations can be too simplified, with respect to e.g. real network protocols*
  - *Live experiments can be too complex. No control over the environment is provided and experiments are therefore hard to e.g. repeat or control*
- ***Network emulation***
  - *Provides a good balance between abstraction and reality*
  - *Enables the use of real end hosts in a controlled environment*

Network Emulation

- *There exists a large number of network emulators*
- *Most emulators are able to emulate bandwidth restrictions and random packet loss*

Deterministic Network Emulation

- *Using deterministic network emulation it is possible to exactly position emulation effects, e.g. packet loss, on a per-packet or per-time unit basis.*
- *Thus, deterministic emulation enables controlled, precise, and reproducible experiments*
- *Current network emulators are, however, not deterministic*

KauNet

- *By extending the well-known Dummynet emulator, KauNet provides deterministic network emulation*

KauNet Overview

KauNet works by applying emulation effects on traffic selected with the IP Firewall in FreeBSD

KauNet has two major components

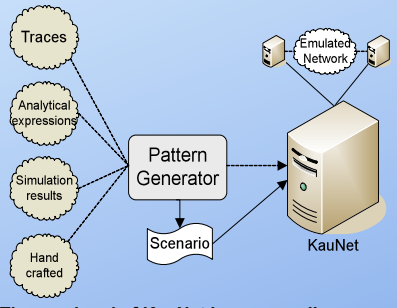
- ***The pattern generation module***
  - *Patterns that model a certain emulation effect, e.g. packet loss, can be created*
  - *Patterns are created using specialized tools or can be imported from other sources (e.g. simulation results or traffic traces)*
- ***The kernel module***
  - *The kernel module reads the specified patterns, and applies the emulation effects that the patterns specify*

Deterministic patterns

- ***Patterns instruct KauNet to apply emulation effects on a certain packet or at a certain point in time***
- ***Currently supported emulation effects are:*** *insertion of bit-errors, packet losses, bandwidth and delay variations*

KauNet Scenarios

- *Several patterns can be combined into a complete emulation scenario*



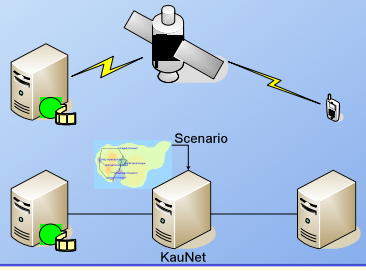
The overhead of KauNet is very small

- *Throughput went down from 368 Mbps to 352 Mbps with KauNet enabled (using a FreeBSD machine as gigabit Ethernet router)*
- *A very large bit-error pattern was used during these experiments, and on average there was at least one bit-error in each packet*

Uses for KauNet

KauNet can be used to model advanced wireless scenarios

- *Emulation of H.264 over satellite is shown below*
- *A regional map is partitioned into several zones with varying packet loss patterns derived from the nature of the terrain and the vehicle speed. Those patterns reflect a DVB-SH-like satellite link*
- *The scenarios are then dynamically loaded into KauNet, to reflect mobiliity*
- *The received video quality can be evaluated*



Opportunistic networking

- *Delay Tolerant Networks (DTNs) are networks of regional networks*
  - *DTNs can not assume node connectivity or any specific network quality (low delays, symmetric data rates, low error rates)*
- *Oppnets are dynamically growing ad hoc networks*
  - *An oppnet tries to enable nearby nodes to participate in a certain activity*
  - *Oppnets can be composed of diverse systems (e.g. P2P systems, sensor networks)*

KauNet and opportunistic networking

- *KauNet can be used to emulate simple opportunistic networks*
- *Current work includes adding functionality for more advanced opportunistic networking support*
  - *Notification of contact opportunities, through trigger patterns, is planned.*
  - *Network reordering support is planned, to support evaluations of opportunistic forwarding*