

# 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

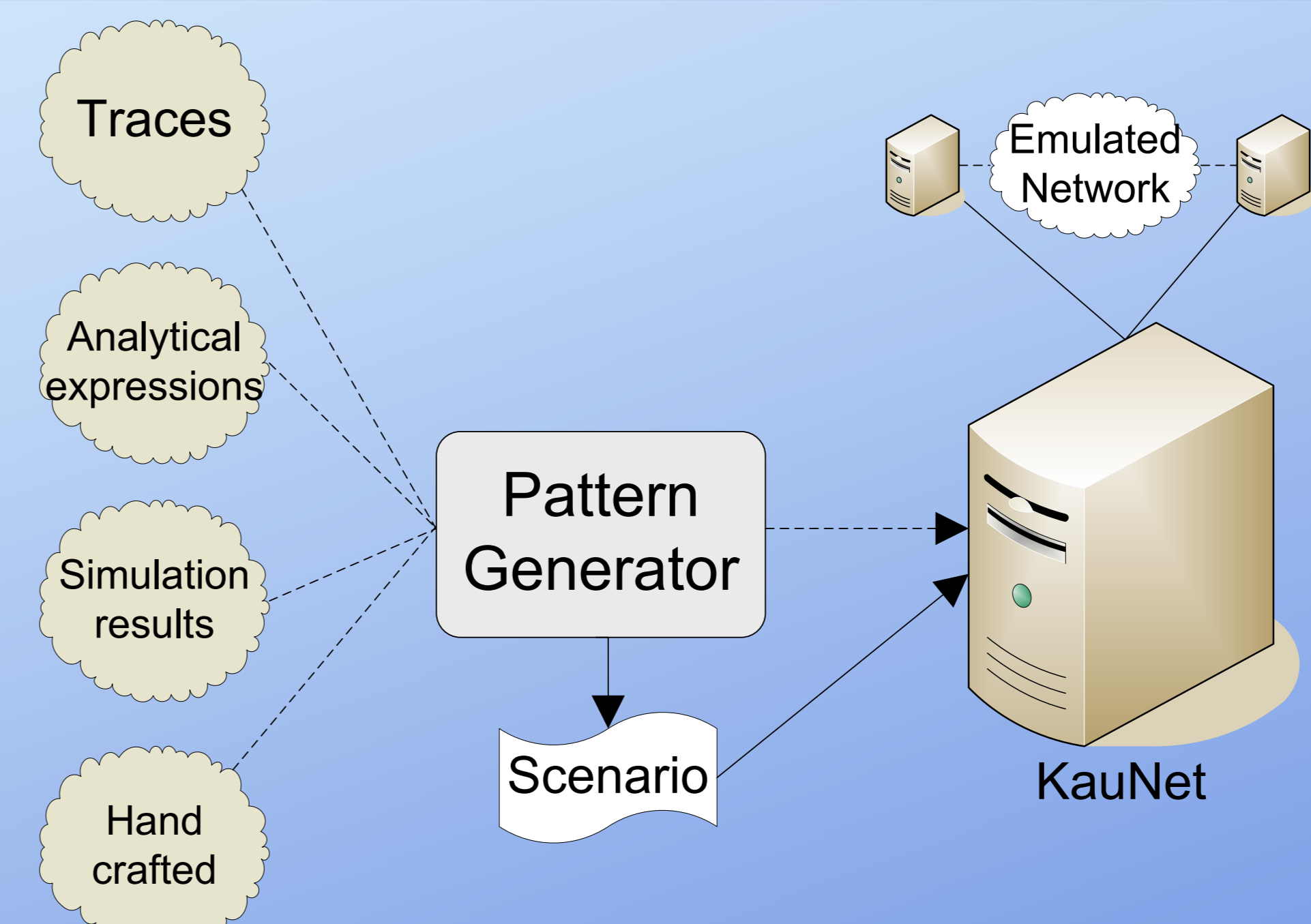
- **The pattern generation module**
  - Patterns that model a certain emulation effect, e.g. packet loss, can be created
  - Patterns are created using specialized tools or can be imported from other sources (e.g. simulation results or traffic traces)
- **The kernel module**
  - The kernel module reads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



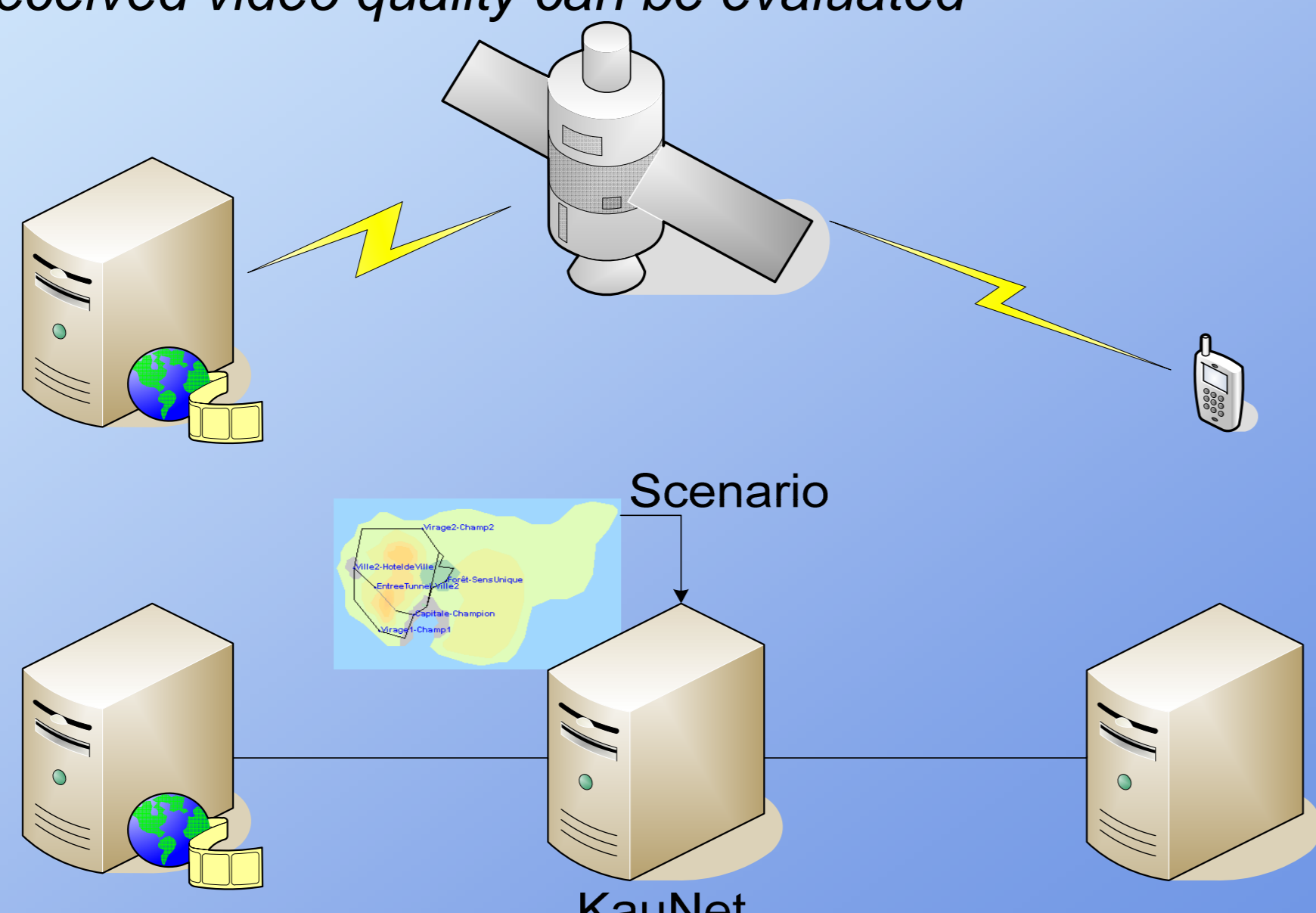
### ➤ The overhead of KauNet is very small

- 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 mobility
- 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