Distack

Towards Understanding the Global Behavior of DDoS Attacks – A Framework for Distributed Attack Detection and Beyond –

Thomas Gamer, Christoph P. Mayer, Martina Zitterbart

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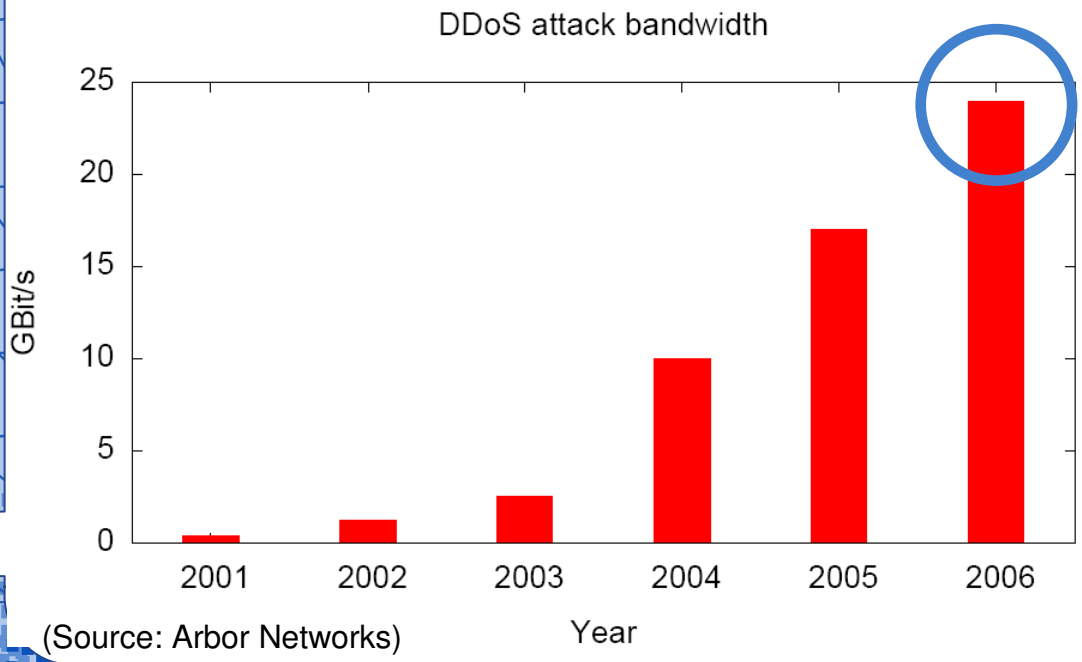
Institute of Telematics, University of Karlsruhe (TH)
Karlsruhe Institute of Technology (KIT)

DDoS – Huge threat to the Internet

„New Zealand teenager controlled botnet of ~~1.3 million~~ 50 computers“ (Heise-Online, Nov. 2007)

„DDoS attacks and worms pose biggest threat to the Internet“ (Worldwide Infrastructure Security Report, Arbor Networks, 2007)



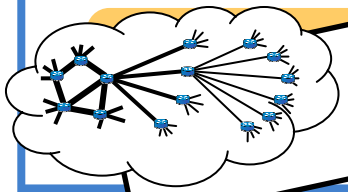
(Source: Arbor Networks)

1.3 million systems send at Ø 19kbit/s each

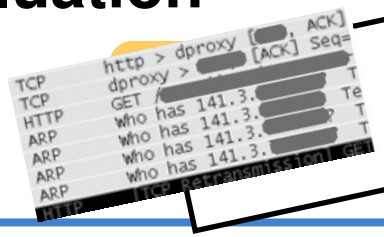
How can you detect and block such low traffic early?

→ Cooperation between detection instances seems promising!

On the way to Distributed Attack Detection



ReaSE



PktAnon

Evaluation

Identification of attacks: anomalies → kin

Local and a

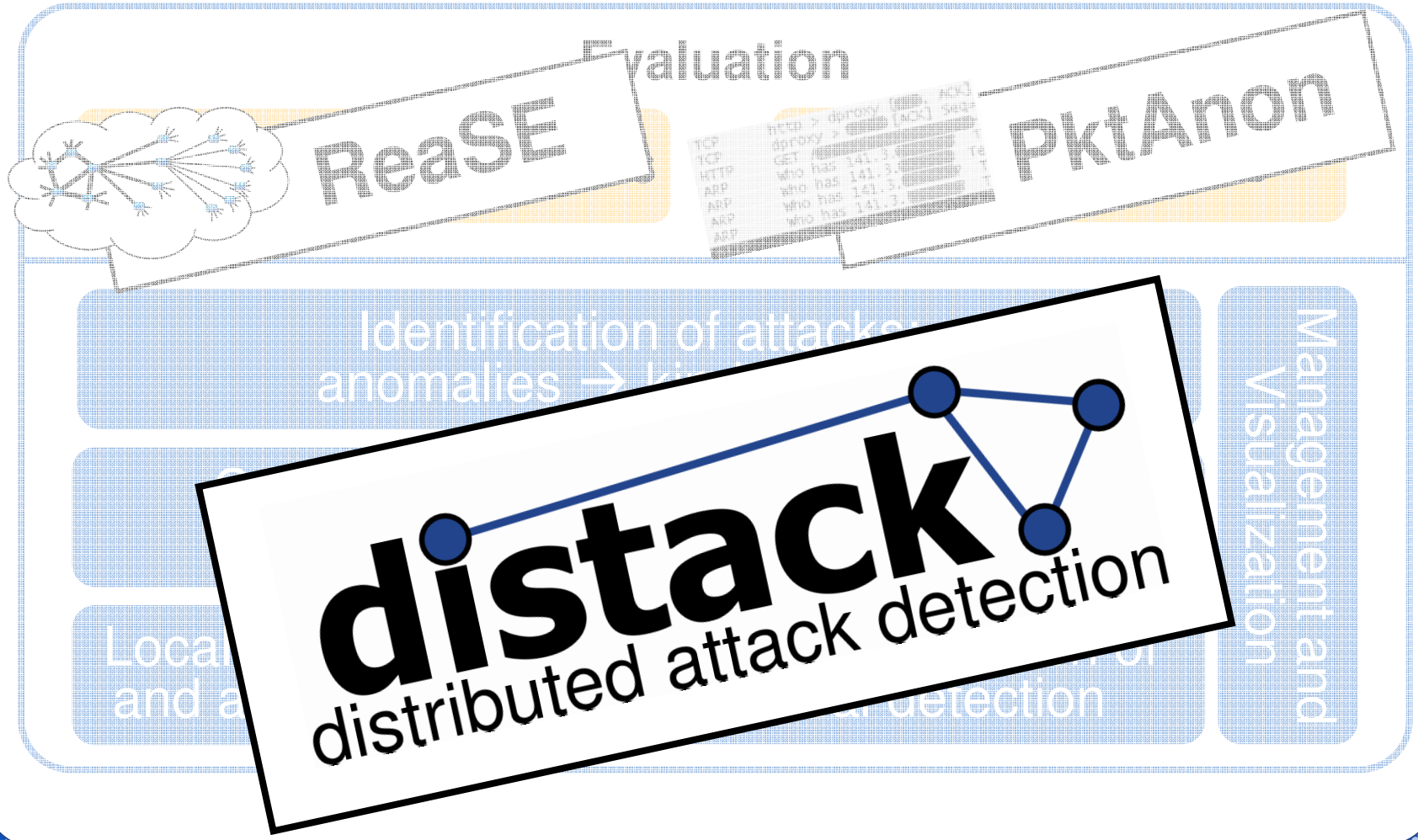
detection

Management and Visualization

distack

distributed attack detection

Distack – Framework for Distributed Large-scale Attack Detection



Why can`t we cope with DDoS?

- Some exemplary issues
  - Little knowledge about global behavior of DDoS
  - Attacks highly distributed. Attack detection and countermeasures mostly not!
  - Few *directly* reusable results

Initial challenge:

Complex development and evaluation of mechanisms for local and *distributed* attack detection and traffic analysis

→ Initial development effort as base for your mechanisms is incredibly high!

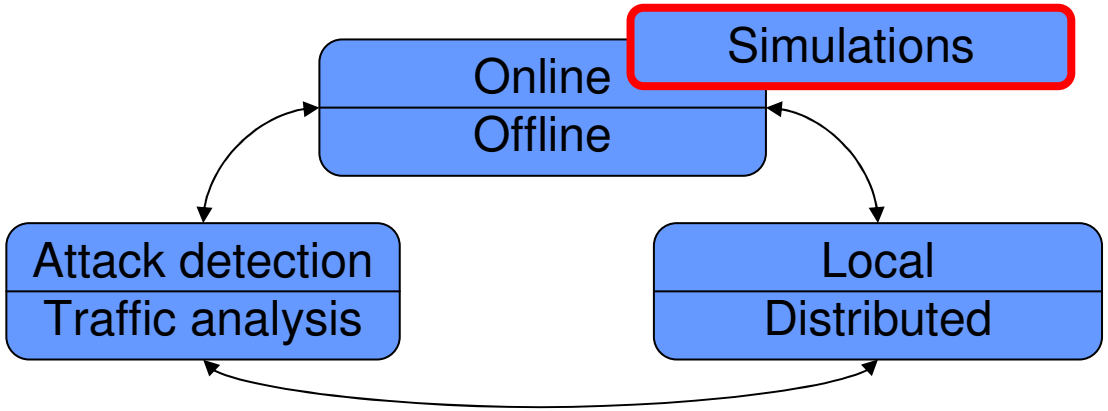
What you can do with Distack

- Attack detection and traffic analysis
  - Rapidly implement and run your attack detection and traffic analysis schemes
  - Lots of reusable modules (e.g. sampling, plotting)
  - Run on live traffic or captured traces
  - Comfortable communication between remote instances → easier distributed detection
- Simulations
  - Run your modules transparently in large-scale simulations
  - Integrates seamlessly with the toolkit OMNeT++/INET/ReaSE

and that`s not even all …

… even more fun with Distack

- Distack use-cases



- Examples
  - *Local traffic analysis*: easily analyze online traffic and traffic traces
  - *Distributed traffic analysis*: several measurement points in the network, report to a central instance

→ There is more than distributed attack detection!

Distack: Distributed attack detection

Framework for distributed attack detection and traffic analysis

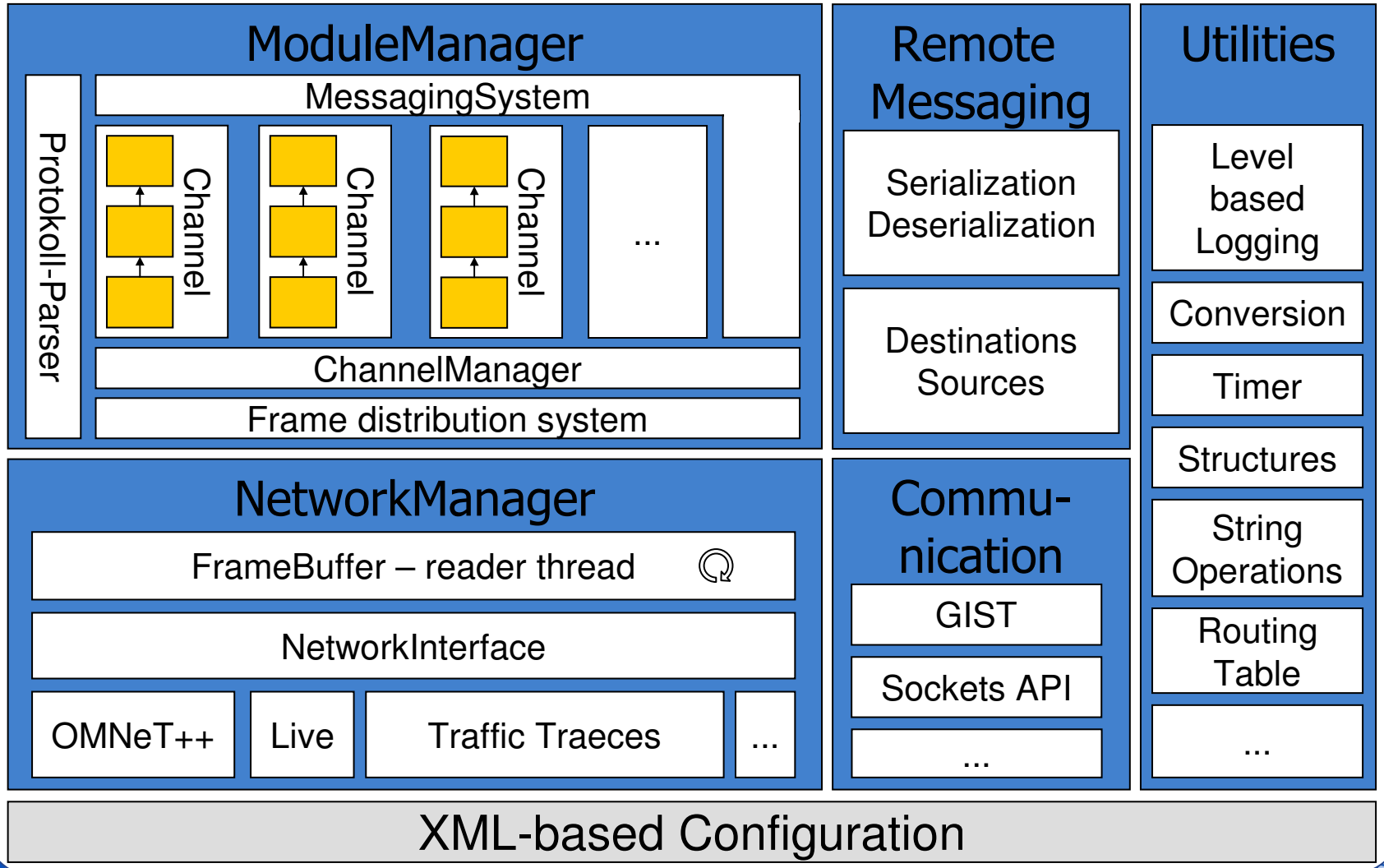
What it gives to *you*

- Fully concentrate on your methods for attack detection and traffic analysis
- Write once run everywhere: Transparently run your methods, e.g. on a PC or in a simulation environment
- High reuse through building blocks
- Great support for your attack detection

Rough Architectural Overview

- Module manager
  - Mechanisms are implemented in small building blocks → *modules*
  - The environment to implement your modules
- Network manager
  - Abstraction from the network
  - Handles the different ways packets come in
- Local and remote messaging
  - Communication for the lightweight modules
  - Data-centric communication, local and remote
- Configuration
  - Flexible way to configure your modules and Distack

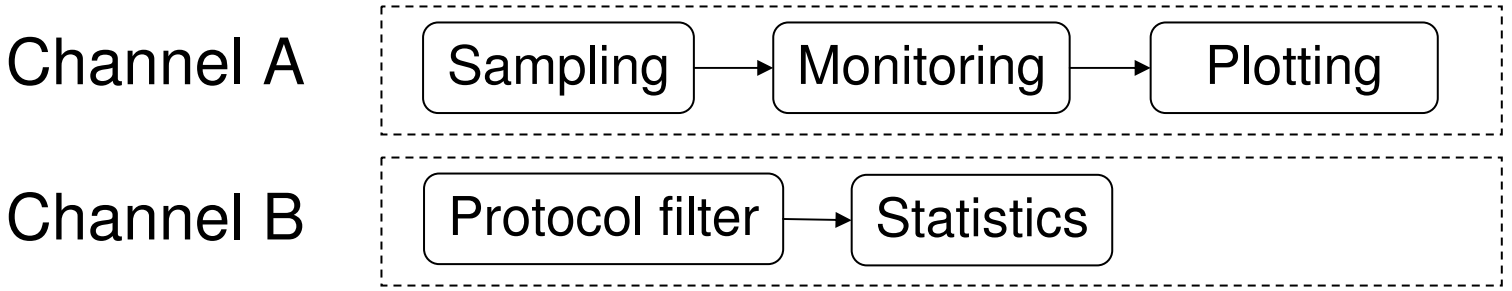
Distack High-level Architecture



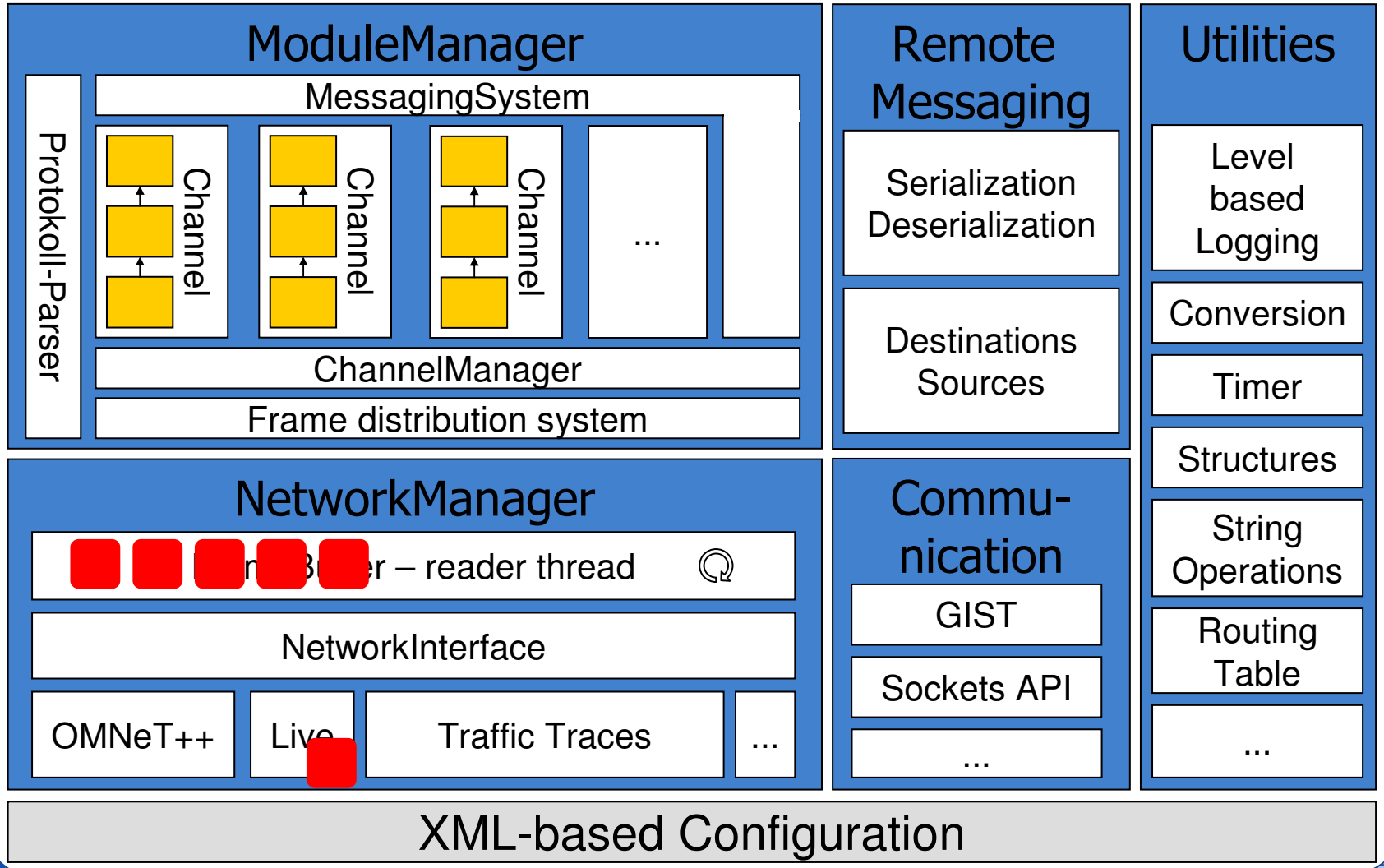
Lightweight Modules

- *Modules*: implement well-defined functionality
  - Small building blocks for high reuse
  - Loaded at runtime on demand
  - Easily configurable (next slide)
  - Perform packet inspection ... or other tasks

  → this is where you implement your mechanisms!
- *Channels*: linear linked modules
  - Create more complex functionality



Packet Processing in Distack



Flexible Configuration

- How can I configure my modules?

Module instantiation and configuration
→ Can use module libraries multiple times with different configuration!

Channels and actual use of modules
→ Flexible grouping of small modules into larger functionality!

Communication

- Modules are leightweight, small, decoupled
  - → Enables high reuse, but how can they interact?
- Data-centric communication between modules
  - Modules register for message they are interested in
    - Modules send out messages
    - Messages delivered to registered modules
  - Module: `*Hmm … interesting information I got here … maybe someone is interested in this*` → send
- Remote communication as easy as local
  - Send messages locally, remotely, or both
  - Transparent message distribution to remote Distack instances

```
MessageSynAckBalance msg(291,33);
sendMessage(msg,REMOTE_DESTINATIONS_NEIGHBOURS);
```

Transparent Abstraction

- Distrack abstracts from traffic sources
  - Live traffic: buffers handle bursty traffic
  - Traffic traces: replayed with original timing
  - Simulated traffic: packet transformation for OMNeT++
- Easy and consistent packet access
  - Traffic live, replayed, or simulated … you don‘t care!
  - Easy and safe access to protocol parsers

```
TcpPacket* tcp = ippacket->getNextPacket();
if(tcp->isFlagSet(TcpPacket::TCP_FLAG_SYN))
   port = tcp->getDestport();
```

  - Supported protocols
    - Ethernet, ARP, ICMP, IPv4, IPv6, MPLS, TCP, UDP
    - More to come. Easy to implement your own!

Integration into simulations

- Few simulations of DDoS attacks and detection

In our opinion the key to understand the global and distributed behavior of DDoS attacks

- Our simulation toolkit
  - OMNeT++: time discrete simulation environment
  - INET Framework: lots of protocols (TCP, UDP, …)
  - ReaSE: topology, self-similar traffic generation, DDoS zombies

- Distack is integrated into this toolkit
  - Packet formats
    - Transparent transformation into Distacks protocol parsers
  - Time domain
    - The simulation time runs different!
  - Modules source code compatible
    - just need to recompile …

Distack is real!

Everything presented here is *running code*!

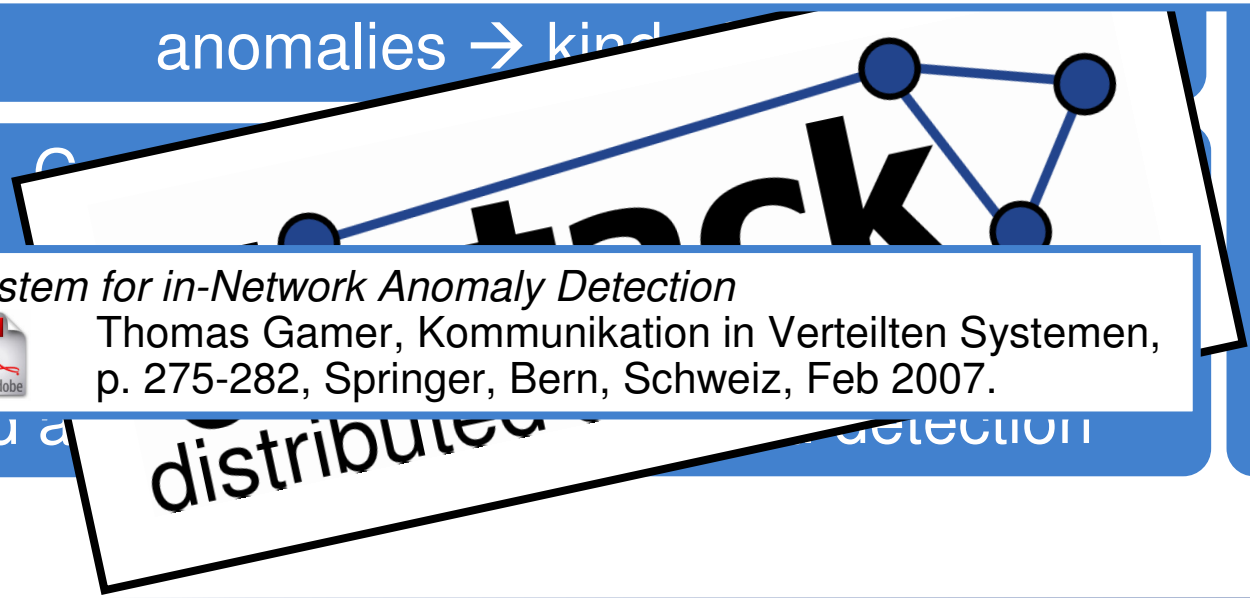
- Go and implement some modules
  - Try it out! E.g. analyze a trace file
  - Use the communication between remote instances
  - There are already several modules available
- Go and do a large-scale simulation
  - Could be DDoS, could be somethings else
  - Find out how easy Distack makes your life!
  - Integrates with ReaSE → coming soon in this talk

What *we* are doing with Distack

Collaborative Anomaly-based Attack Detection
Thomas Gamer, Michael Scharf, and Marcus Schöller, Proceedings of 2nd International Workshop on Self-Organizing Systems (IWSOS 2007), p. 280-287, Springer, Sep 2007.

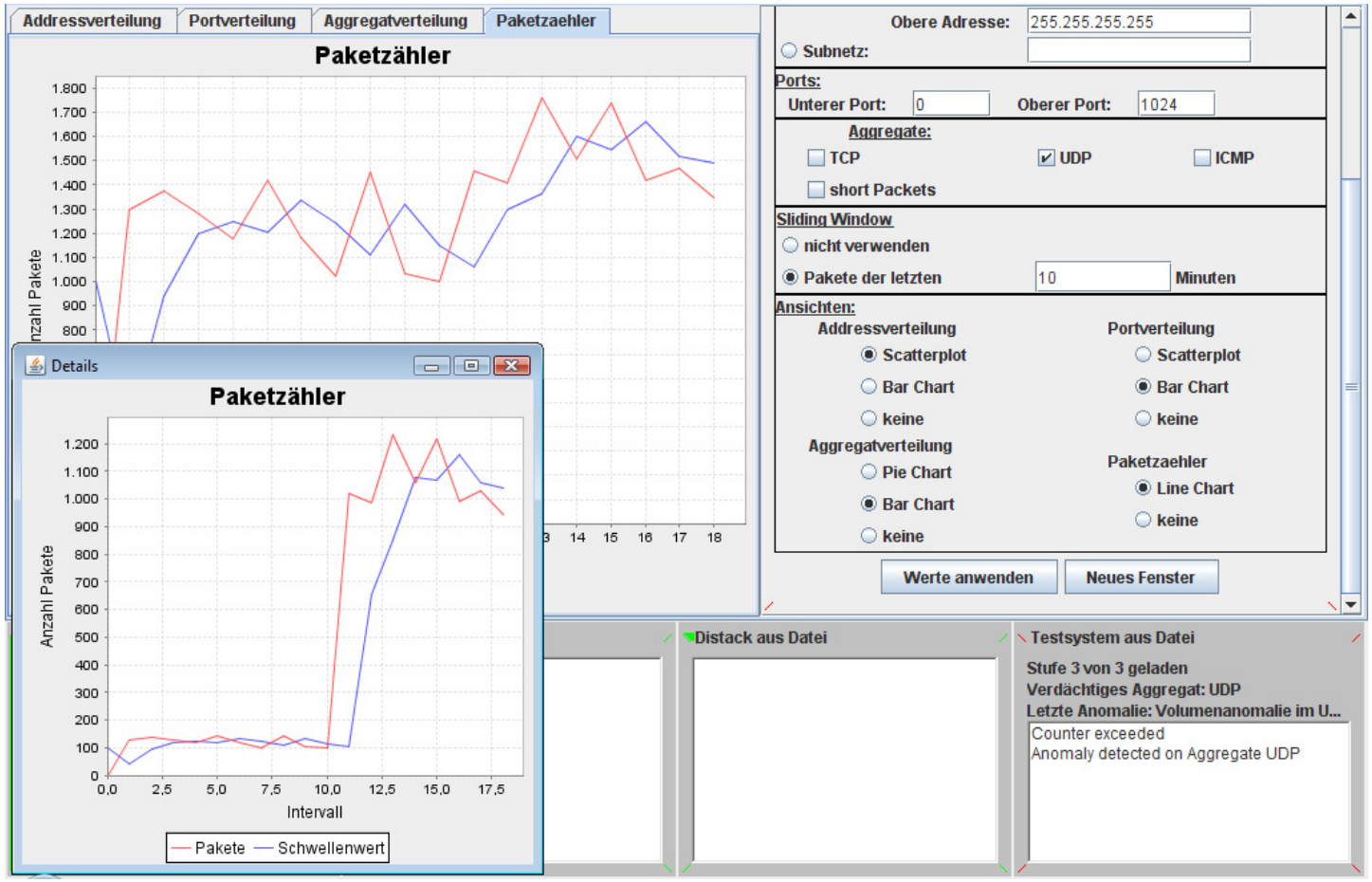
anomalies → kind

Management and Visualization



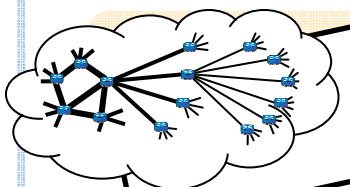
A System for in-Network Anomaly Detection
Thomas Gamer, Kommunikation in Verteilten Systemen, p. 275-282, Springer, Bern, Schweiz, Feb 2007.

What *we* are doing with Distack



Management and Visualization

ReaSE – Realistic Simulation Environment



ReaSE

Evaluation

PktAnon

Identification of attacks-
anomalies ⇒ b...

Loca...
and a...

...detection

Management and Visualization

distack
distributed attack detection

Realistic Simulations

- We want …
  - to understand the global behavior of DDoS attacks
  - evaluate our mechanisms implemented in Distack

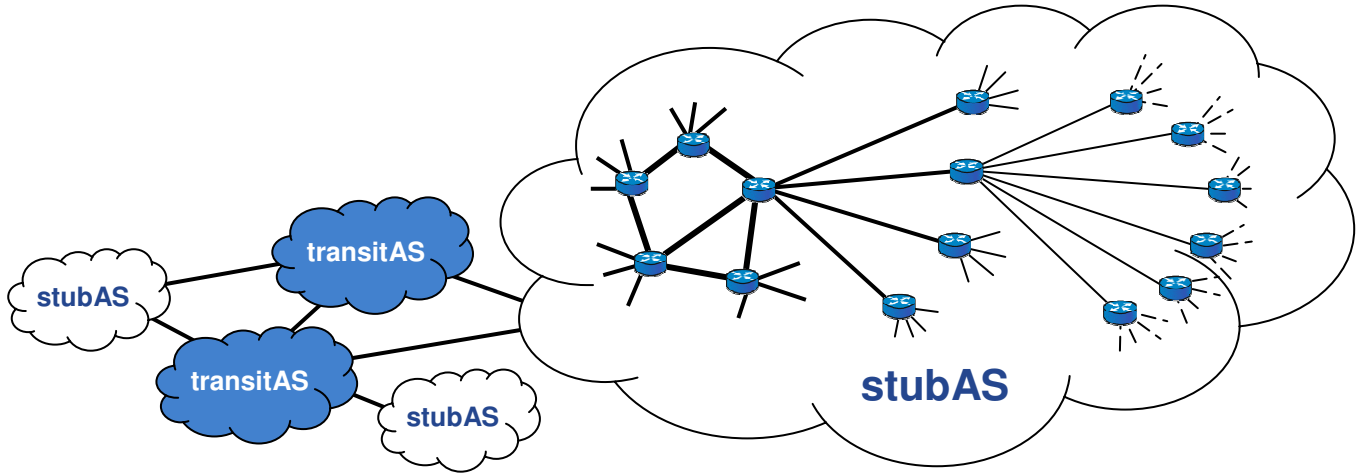
  → *on a large-scale!*

- Using real systems is *extremly* costly!
  - Where to get e.g. 10.000 machines from?
  - Use a real network? We will execute DDoS attacks!

→ Simulations
  - Topologies that match todays Internet infrastructure
  - Realistic background traffic, malicious DDoS traffic

Network Topology

- How does todays Internet topology look like?
  - Power-law distribution in node degree
    - Lots of nodes with low node degree
    - Few nodes with high node degree
  - Hierarchical structure
    - Autonomous Systems (stub/transit) with routers
    - Based on Zhoua et al. ICCCAS06, Li et al. SIGCOMM04



Network Traffic

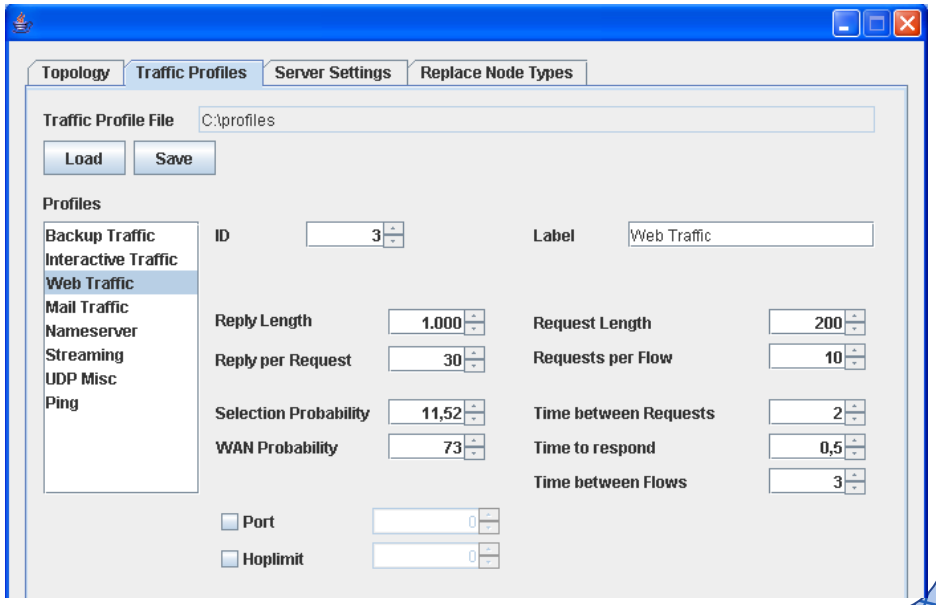
- Legitimate traffic as well as…
  - Self-similar behavior
    - Heavy-tailed ON/OFF intervals as well as packet sizes
  - Reasonable mix of different kinds of traffic

  → Traffic profiles define flow behavior

- … malicious traffic
  - Evaluate the attack detection system
  - Used real-world tools and ported their behavior
    - DDoS attacks: Tribe Flood Network
    - Worm propagations: Code Red v1

ReaSE Summary

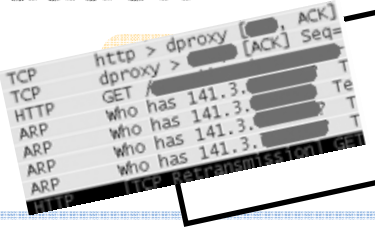
- ReaSE combines topology and traffic generation for realistic simulation environments
  - Based on up-to-date solutions
  - Includes generation of malicious traffic
  - Integrates with OMNeT++ and INET Framework
- GUI helps to …
  - create topologies
  - define traffic profiles



PktAnon – Traffic Anonymization

Evaluation

ReaSE



PktAnon

Identification of attacks-
anomalies ⇒ ki

Loca
and a

Management and visualization

distack

distributed attack detection

PktAnon – Traffic Anonymization

- How it all began: *We wanted to record network traffic at an ISP gateway to evaluate the attack detection mechanisms* …

→ Anonymization of network traffic

- Sharing recorded traffic traces with third parties
- Legal reasons, protect users, protect your network infrastructure, …

- Existing tools not flexible enough
  - Have been built out of a specific need

→ PktAnon is generic and fully flexible!

Anonymization profiles

- Anonymization profiles
  - Allow complete flexibility in the anonymization

  → every protocol field can be anonymized!

```
<TcpPacket>
  <TcpSourceport anon=AnonHashSha1/>
  <TcpSegnum     anon=AnonIdentity/>
...
```

- Even more flexibility
  - Input and Output piping (→ live anonymization!)
  - Output traces well-formed (checksum, length field)
  - Many anonymization primitives and protocols
- Current and outlook
  - FreeBSD package, liveHEX security CD, OpenPacket.org
  - Call to the community for defining standardized anonymization profiles with different security levels

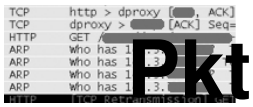
Summary and Conslusion

→ *Road towards distributed attack detection and understanding the global behavior of DDoS is stony!*

- We have developed tools to flatten this way
  - Did not build them the way *we* needed them
    → built them generic and flexible
  - Now they simplify our daily work
    …and they can simplify *your* work!

distack distributed attack detection — Framework

ReaSE — Realistic Simulation Environment



PktAnon — Profile-based Packet Anonymization

Thank you for your Attention!

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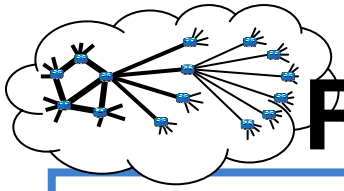
distributed attack detection

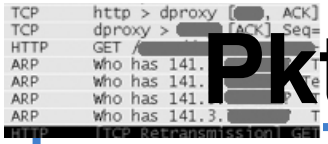
www.tm.uka.de/distack

Distack – A Framework for Large-scale Anomaly-based Attack Detection
Thomas Gamer, Christoph P. Mayer, and Martina Zitterbart
SECURWARE08, Cap Esterel, France, Aug 2008.



ReaSE www.tm.uka.de/rease

Realistic Simulation Environments for IP-based Networks
Thomas Gamer and Michael Scharf, 1st International Workshop on OMNeT++, Marseille, France, Mar 2008.



PktAnon www.tm.uka.de/pktanon

PktAnon – A Generic Framework for Profile-based Traffic Anonymization
Thomas Gamer, Christoph P. Mayer, and Marcus Schöller
PIK 2-2008 (Journal), Apr 2008.