Hardware-Accelerated Flexible Flow Measurement

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Part I

Introduction and Related Work

Introduction

Motivation

- Networks are difficult to understand without monitoring.
- Networks are complex and prone to failures and attacks.
- Monitoring of multi-gigabit networks is a challenging problem.

What We Need?

- Real-time traffic monitoring, QoS measurement.
- Anomaly detection, security analysis and forensics.
- Capacity and topology planning, ...

Standard Flow Monitoring Solutions

Routers – CISCO, Juniper, Enterasys, ...

- Busy with routing, flow monitoring addon feature.
- Flow monitoring is not implemented in all models.
- Fixed placement, possible target of attacks.
- Often mandatory sampling, no advanced features.

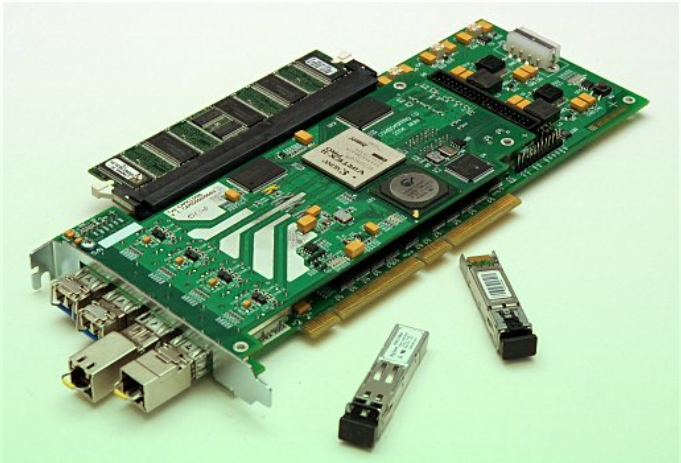
Flow Probes – nProbe, fprobe, softflowd, ...

- Based on commodity HW – PC and standard NICs.
- Solution when flow monitoring required but not available.
- Limited performance (PCAP, PCI-X) and stability problems (packet drops, time stamps issues, ...).
- Requires extra system tuning and system/tools hacks.

Hardware Acceleration

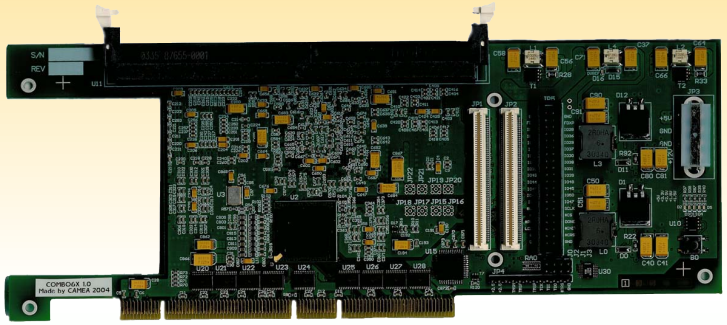
- PC is flexible but not fast enough to process gigabit links.
- Hardware is fast but not easy to use.

$\Rightarrow$ Combination of PC and programmable hardware FPGA (*Field-Programmable Gate Array*).

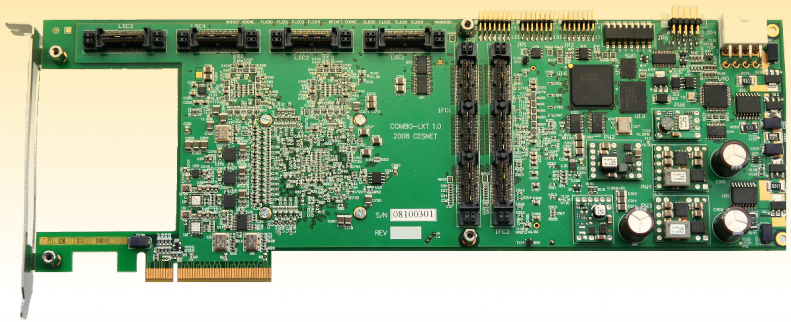


COMBO6X and COMBOv2 Card Family

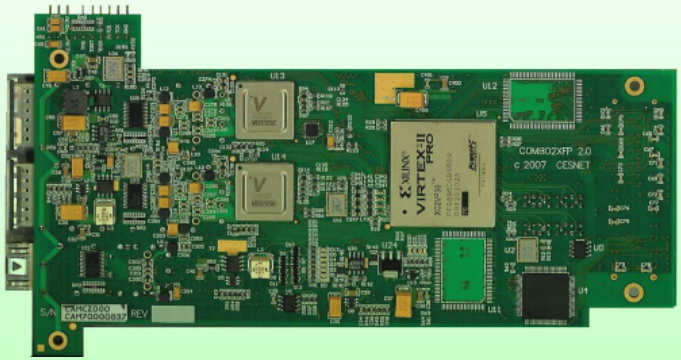
- Time-critical parts of monitoring are processed in FPGA.
- New cards designed for 10+ Gb/s speeds (up to 40-100 Gb/s).



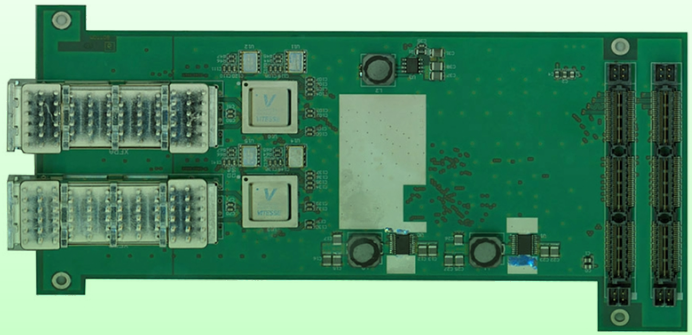
COMBO6X front side



COMBO-LXT front side



COMBO-2XFP2 2x10 Gb/s



COMBOI-10G2 2x10 Gb/s

FlowMon Probe - Short Overview

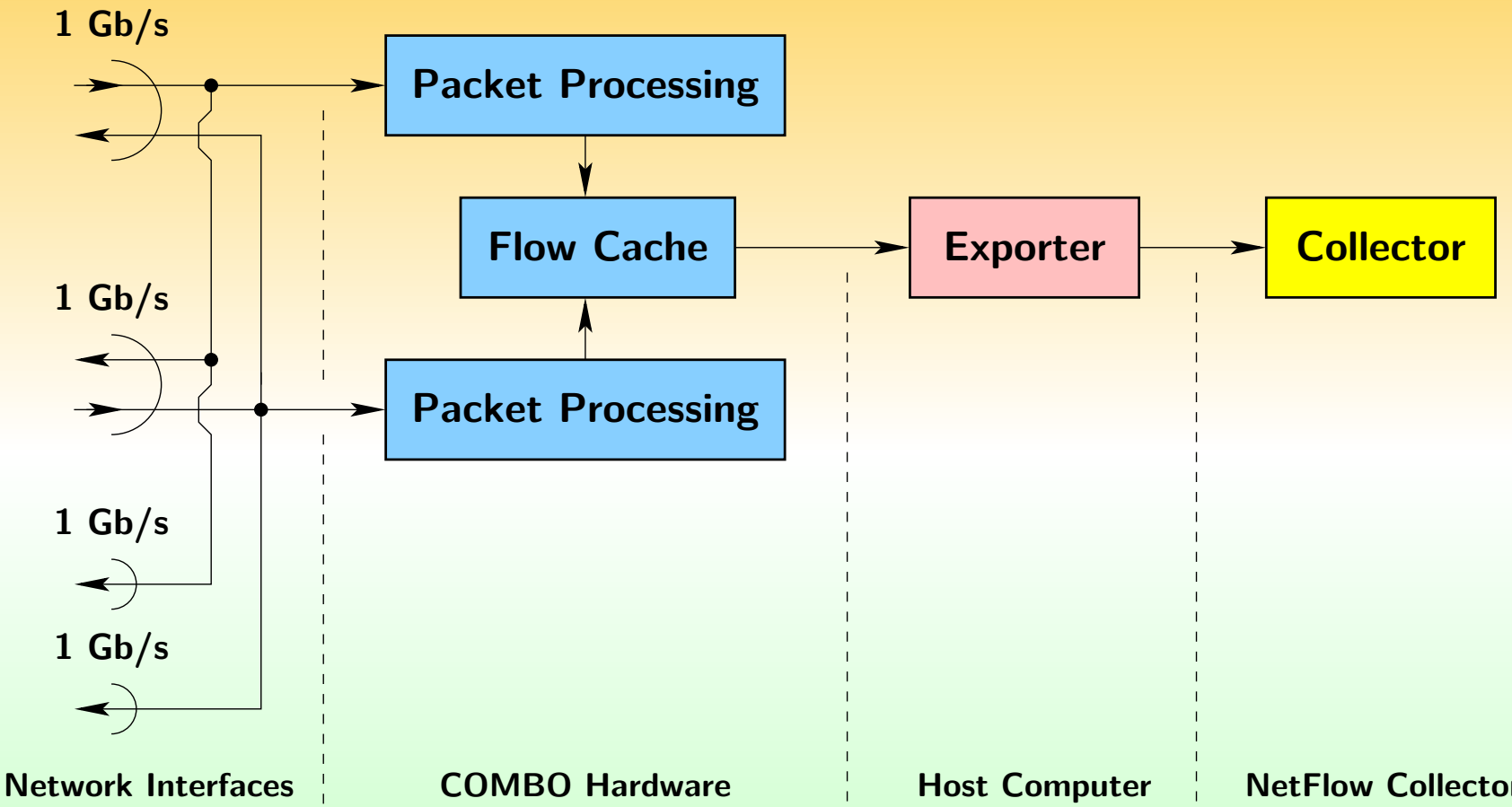
Goals

- Usage of hardware acceleration for IP flow measurement.
- Implementation of advanced methods for network monitoring.

Features

- Mobile network appliance, no fixed network position.
- Independent of network infrastructure used.
- Based on Linux $\rightarrow$ "unlimited" addon smart extensions.
- Observes whole network traffic under all conditions.
- Standard compliant - NetFlow v5/9 and IPFIX.
- Secure configuration via NETCONF web interface or SSH.

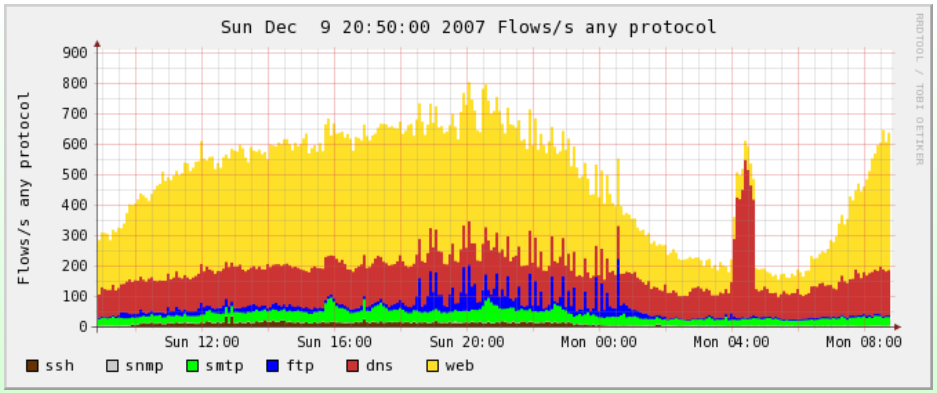
FlowMon Probe - Architecture



FlowMon probe block schema.

FlowMon Probe - Summary

- Stable firmware and SW for COMBO6X HW.
- Mature technology for standard NetFlow v5/9 monitoring.
- Scientific projects – flow monitoring, anomalies detection.
- Recognized by GÉANT2 as part of security toolset + NfSen.



Detailed network view with NetFlow data.

Part II

Flexible Flow Measurement

Motivation – I

New Measurement Requirements

- QoS – statistics of interarrival packet interval, ...
- Application identification – statistical fingerprinting, ...
- IDS – pushed number of bytes, number of zero window probes, sample of payload, ...
- First N packets statistics, averages, variances, histograms, ...

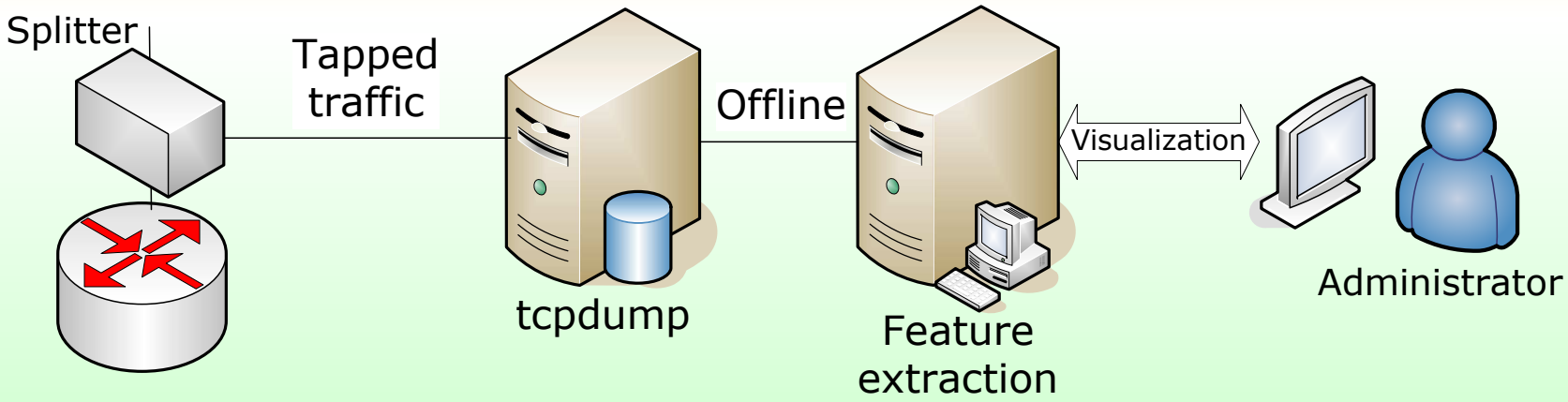
Current Flow Measurement

- Requirements not met with traditional 5-tuple NetFlow.
- IPFIX – defined and vendor-specific Information Elements.
- New vendor/user-specific Information Elements are inevitable.

Motivation – II

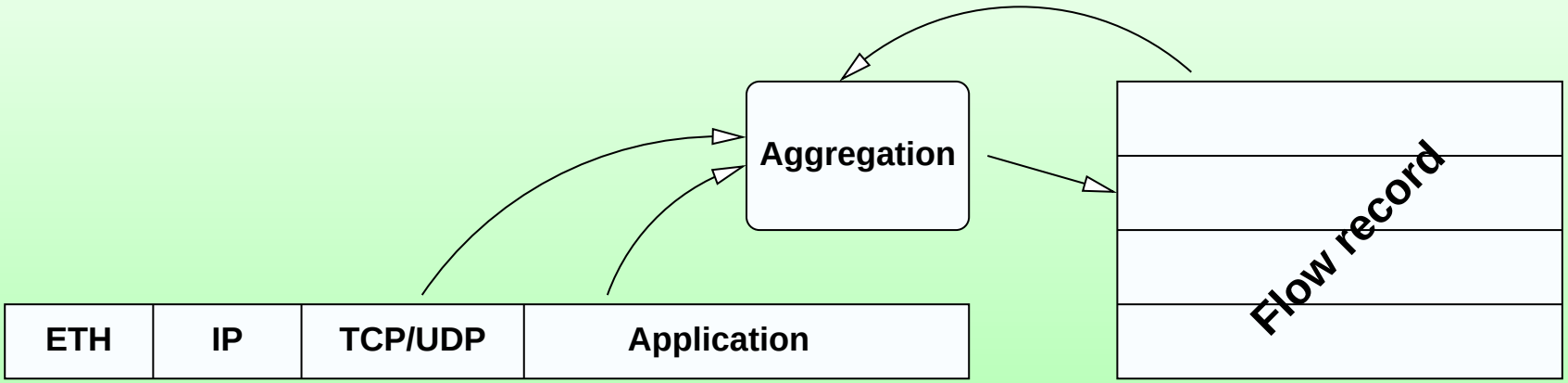
Current Practice of User-Specific Measurement

- Packet sniffing with tcpdump, wireshark, . . .
- Offline aggregation by arbitrary scripts.

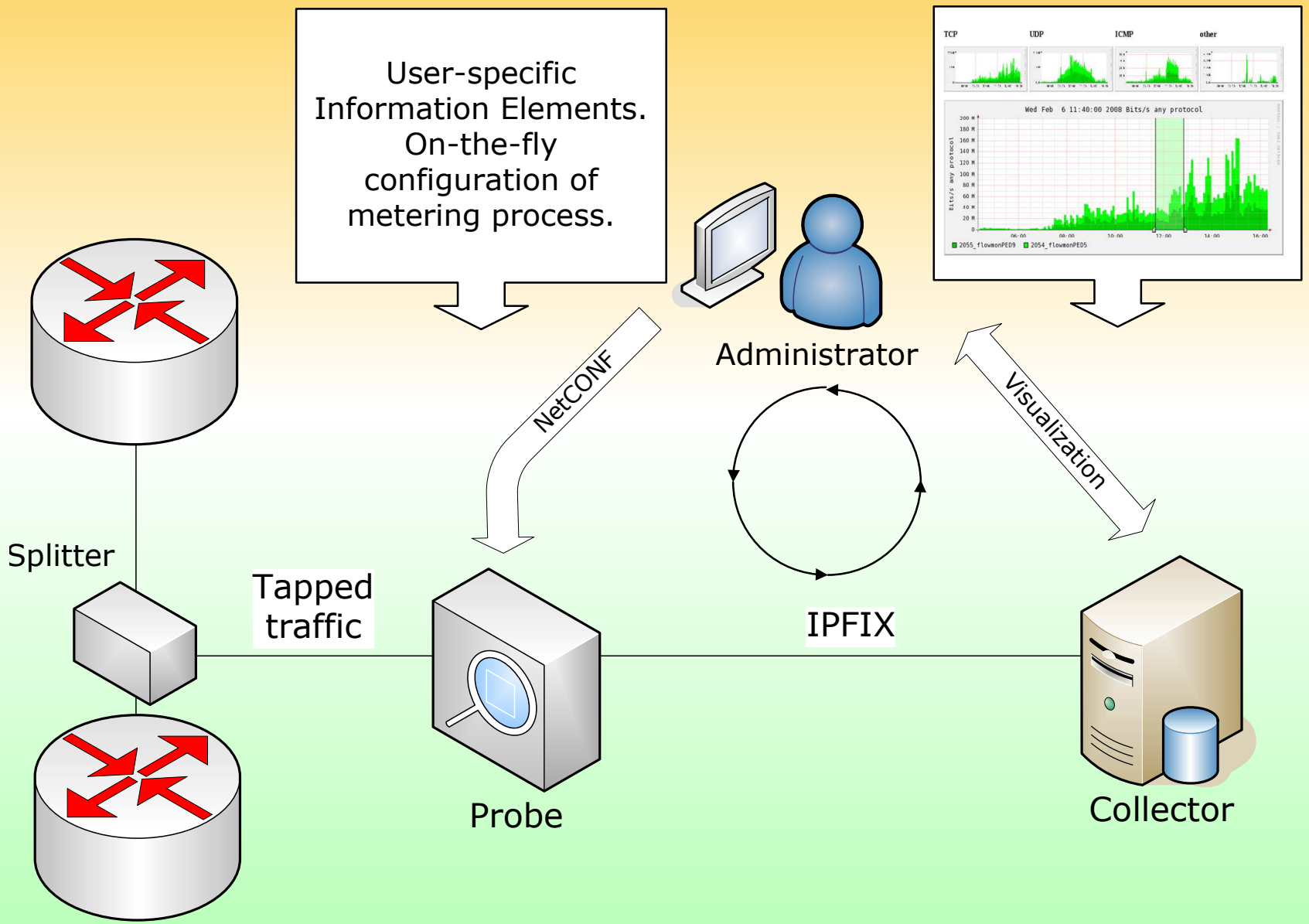


Challenge of Flow Monitoring Infrastructure

- Measurement and collection of ad-hoc Information Elements has not been fully addressed.
- The goal should be to specify new (non-existing) Information Element and setup exporter and collector to report it automatically.
- **Dynamic** and flexible flow measurement
  $\longrightarrow$ Tell me what you want and I will deliver.
- Steps to define new Information Elements (IE):
  1. Select packet header fields and IE to work with.
  2. Specify how to aggregate these fields into a new IE.
  3. Define triggers.

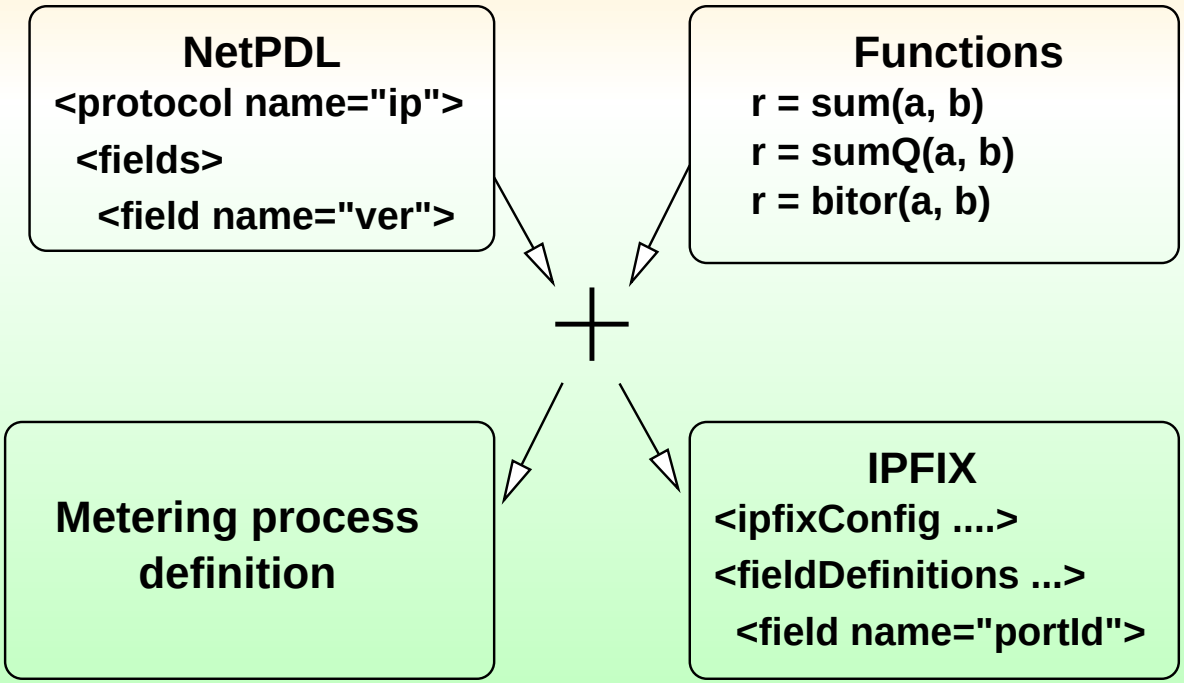


Measurement Framework



Dynamic Flow Measurement

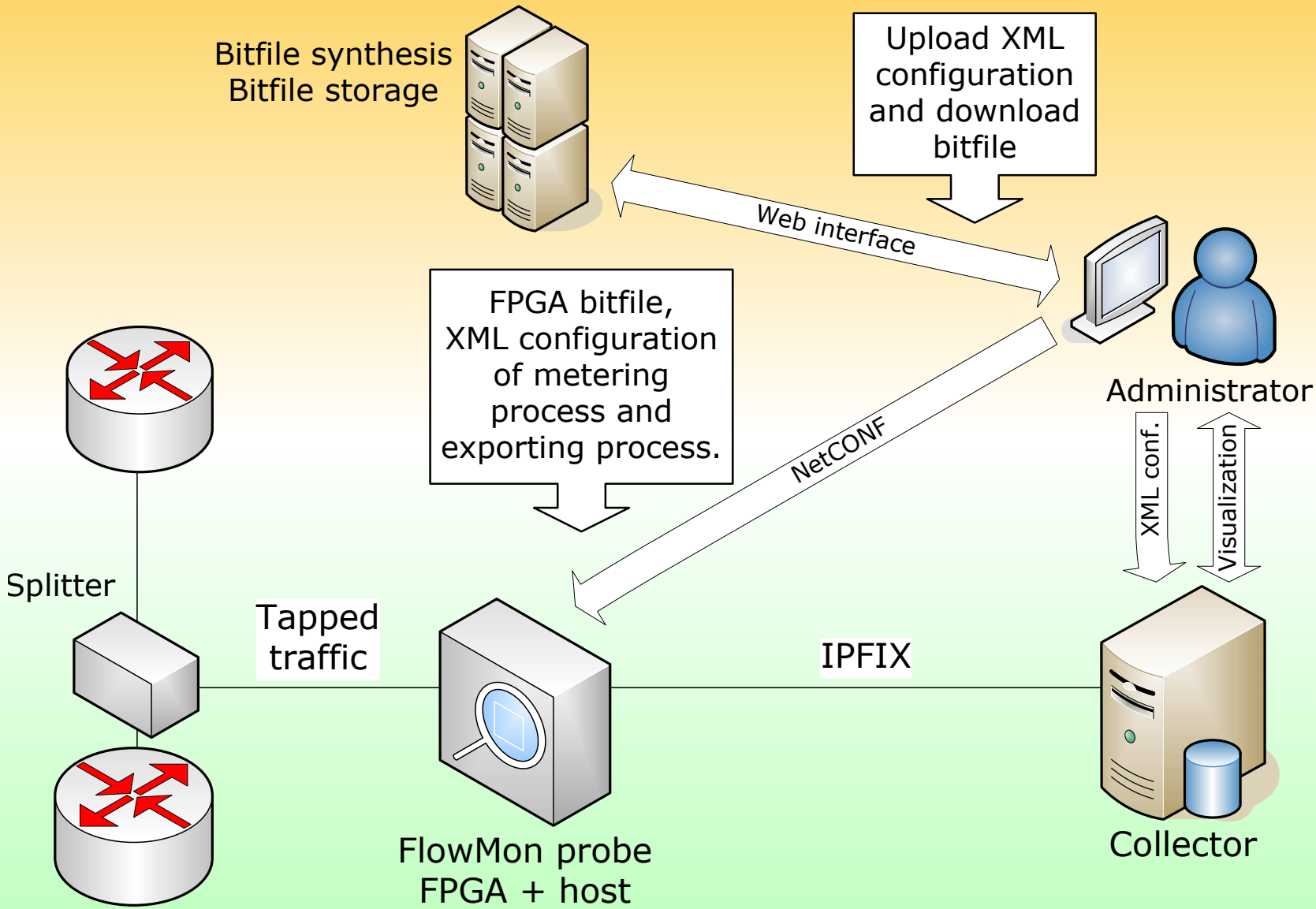
- Standardized definition of packet structure – NetPDL (*Network Protocol Description Language*).
- Standardized definition for flow record – IPFIX.
- Standardized definition of operation – simple C function.



Design Challenges of the System

- Flexibility and performance of metering process.
  - Possible solution: Utilization of network card with FPGA.
  - Flexible, yet wired functionality.
  - Line rate processing.
- Collector for dynamic flow measurement.
  - Sufficient performance.
  - Allows not only to store flow records but also understand and visualize information encoded.

System Architecture



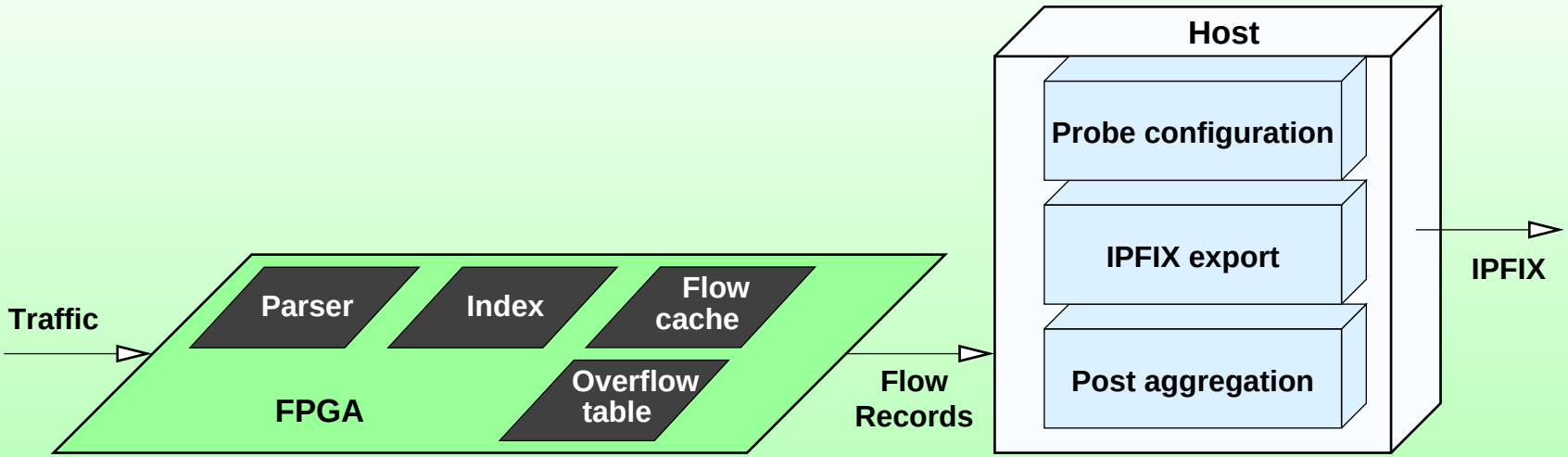
Probe Architecture

Firmware - FPGA

- Packet parsing engine – hardcoded Finite State Machine.
- Indexing – hash and overflow scheme.
- Fast (line-rate) flow record update engine.
- Flow cache – large SSRAM + internal memory in FPGA.

Software

- Aggregates sliced flows (if definition allows).
- Export flows.



Flexible FlowMon

Our Testbed and Deployment Network

- HW testers for line-rate (worst-case) testing.
- NREN (*National Research and Education Network*) backbones, university campuses and ISP networks.
- Sustained live traffic 4-5 Gb/s, 700 kpkt/s, 30 kflows/s.
- Long-time NetFlow monitoring - probes and collectors.

Performance Expectation

- Measurement of 10 Gbps without packet loss.
- Timestamp (< 60 ns) able to distinguish consequent packets.
- Cover IPFIX and allow for user-specific Information Elements.
- Variety of optional sampling methods.

Part III

Future Work and Conclusion

Flexible FlowMon – Summary

State of Development

- Module for assembling parsing engine – ready.
- Module for assembling flow record update engine – ready.
- NETCONF data path – ready.
- IPFIX exporter (user-defined flow record) – work in progress.
- IPFIX collector (user-defined flow record) – work in progress.

HW and SW Support

- Firmware for COMBO6X + COMBO-2XFP2 - 2x10 Gb/s.
- Linux OS - CentOS 5.

Thank You For Your Attention

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