Hardware Acceleration in Monitoring of Gigabit Networks: The SCAMPI project

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Scampi overview

- 2.5 year 5th Framework project
- Started April 2002, extended to May 2005
- 9 partners:

  CESNET, FORTH, FORTHNET

  IMEC, Leiden University, Masaryk University

  NETIKOS, TERENA, UNINETT

Main goals:

- Development of a high-performance intelligent monitoring adapter for 10 Gbps
- Development of an open and extensible architecture for network monitoring
- Development of monitoring and measurement tools
- Investigate strategies and methodologies for monitoring systems operating at 100 Gbps and beyond

Applications

- Intrusion detection - uses Snort signatures
- QoS application - packet loss, jitter, one way delay
- DOS attack detection - based on anomaly detection
- Flowrep - generic report generator with a web frontend for Netflow/IPFIX records

MAPI (Monitoring Application Programming Interface)

- Design goals:

  Make it quick and easy to implement new monitoring applications

  Support for multiple concurrent users and applications

  Global optimization - optimize processing of packets based on all applications from all users

  Transparent support for different hardware adapters

  Easy to extend - New drivers, function libraries

- Support for: SCAMPI adapter, DAG cards, NIC

- Network flow

  mapi_create_flow

  Initially all packets seen on the network

- Apply functions to a flow

  mapi_apply_functions

  BPF filter, string search, packet counter, byte counter, Netflow, jitter etc.

- Read results

  mapi_read_result

  mapi_get_next_pkt

- MAPId Daemon that communicates with hardware devices and processes packets in software

Why Programmable Hardware

- Todays computers are not able to process traffic monitoring at wire speeds

  PCI bus throughput

  interrupt latency

  slow disk access

- . . . hardware acceleration

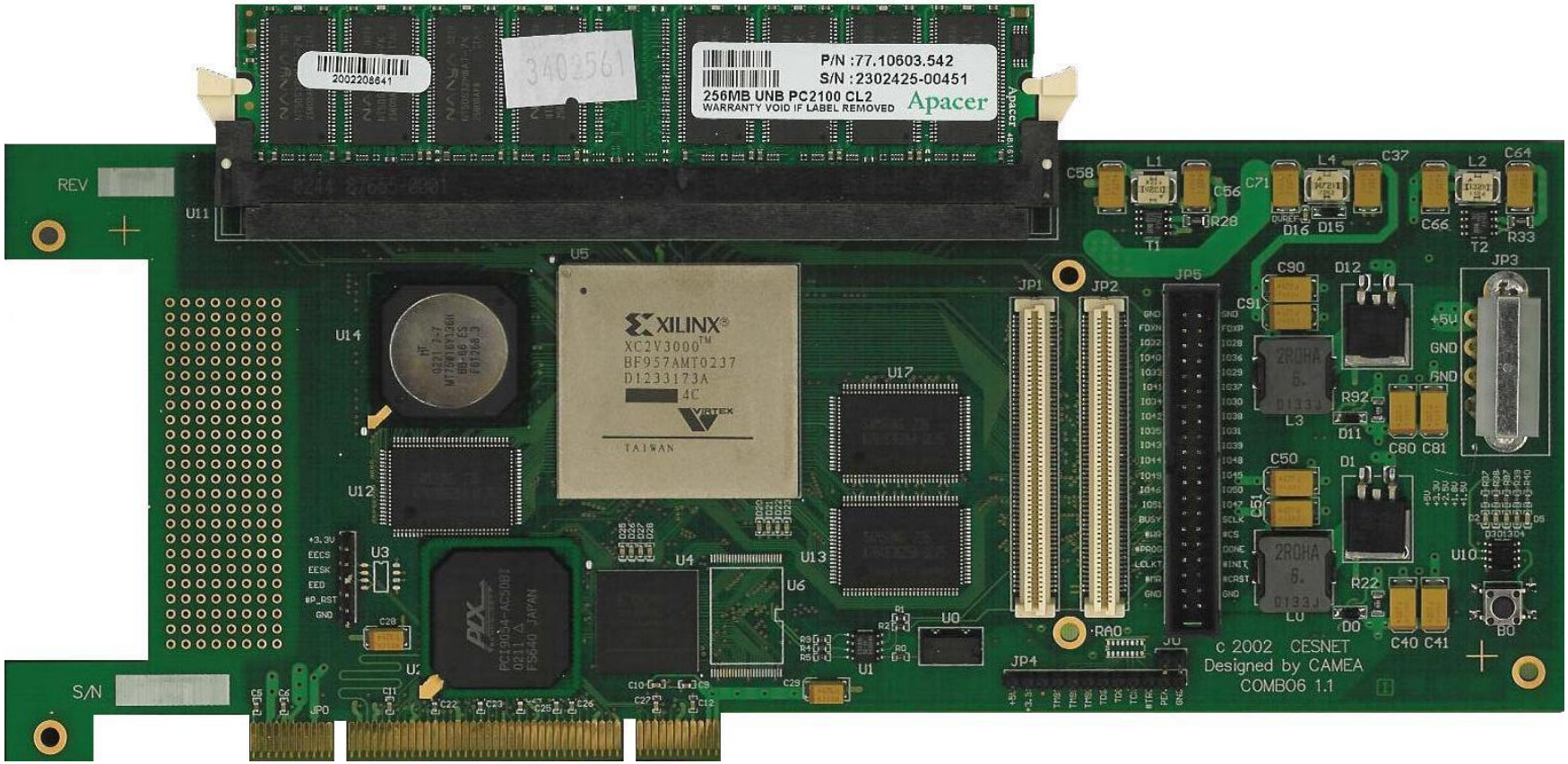
- ASICs are not flexible enough do not follow changing conditions of the Internet

- . . . programmable hardware acceleration

Solution

SCAMPI adapters - based on COMBO family developed by CESNET and Masaryk University

COMBO6


P/N :77.10603.542
S/N :2302425-00451
256MB UNB PC2100 CL2
WARRANTY VOID IF LABEL REMOVED
Apacer
XILINX
XC2V3000
TAIWAN
c 2002 CESNET
Designed by CAMEA
COMBO6 1.1
REV
S/N

COMBO6

Combination of programmable hardware and standard integrated circuits

- XILINX FPGA (VIRTEX II 3000-6000)
- CAM, 3xSRAM, DDRAM, EEPROM
- PLX, power supply
- Exchangeable interface cards

Status - fully operational, will be replaced with COMBO6X

COMBO6X

- 2xXILINX II PRO, 3xPower PC - processors inside FPGA can bring new ideas in network monitoring
- Using of FPGA and PCI core instead of PLX chip - speed of PCI bus goes up at least to 4Gb/s. With PCI-X core could go up 8Gb/s
- 3xSRAM, 1xCAM,1xDRAM
- The COMBO6X with FPGA and PCI core is ready for redesign to Express PCI

Status - in manufacturing phase

COMBO-4MTX


c 2002 CESNET
Designed by CAMEA
COMBO-4MTX 1.0
CM-002
U3
U2
U8
U9

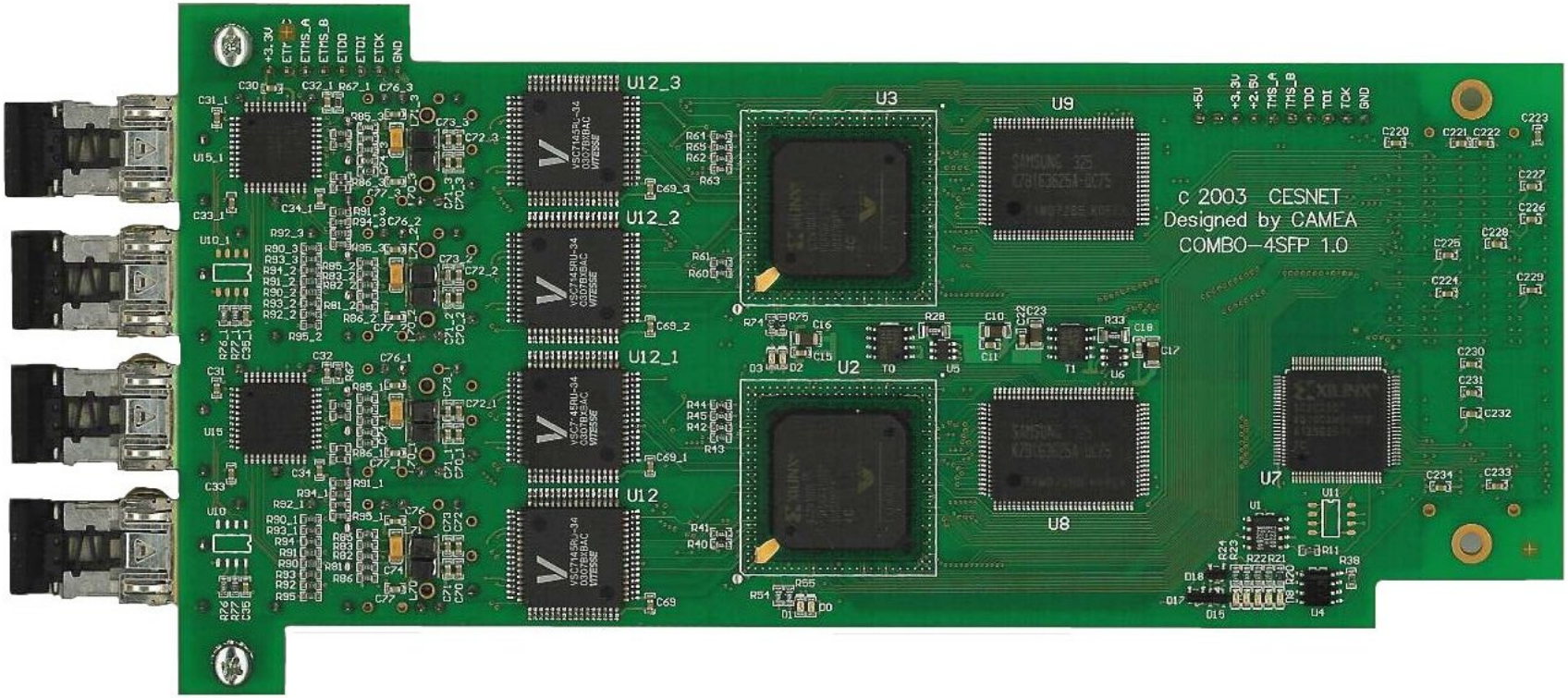
COMBO-4MTX

Interface card with 4x1Gb/s copper ports

- 2xXILINX FPGA (VIRTEX II 1000-3000)
- 2xSRAM, EEPROM
- 4x1Gb ports

Status - fully operational

COMBO-4SFP


c 2003 CESNET
Designed by CAMEA
COMBO-4SFP 1.0
U12_3
U12_2
U12_1
U12
U3
U9
U2
U8
U7

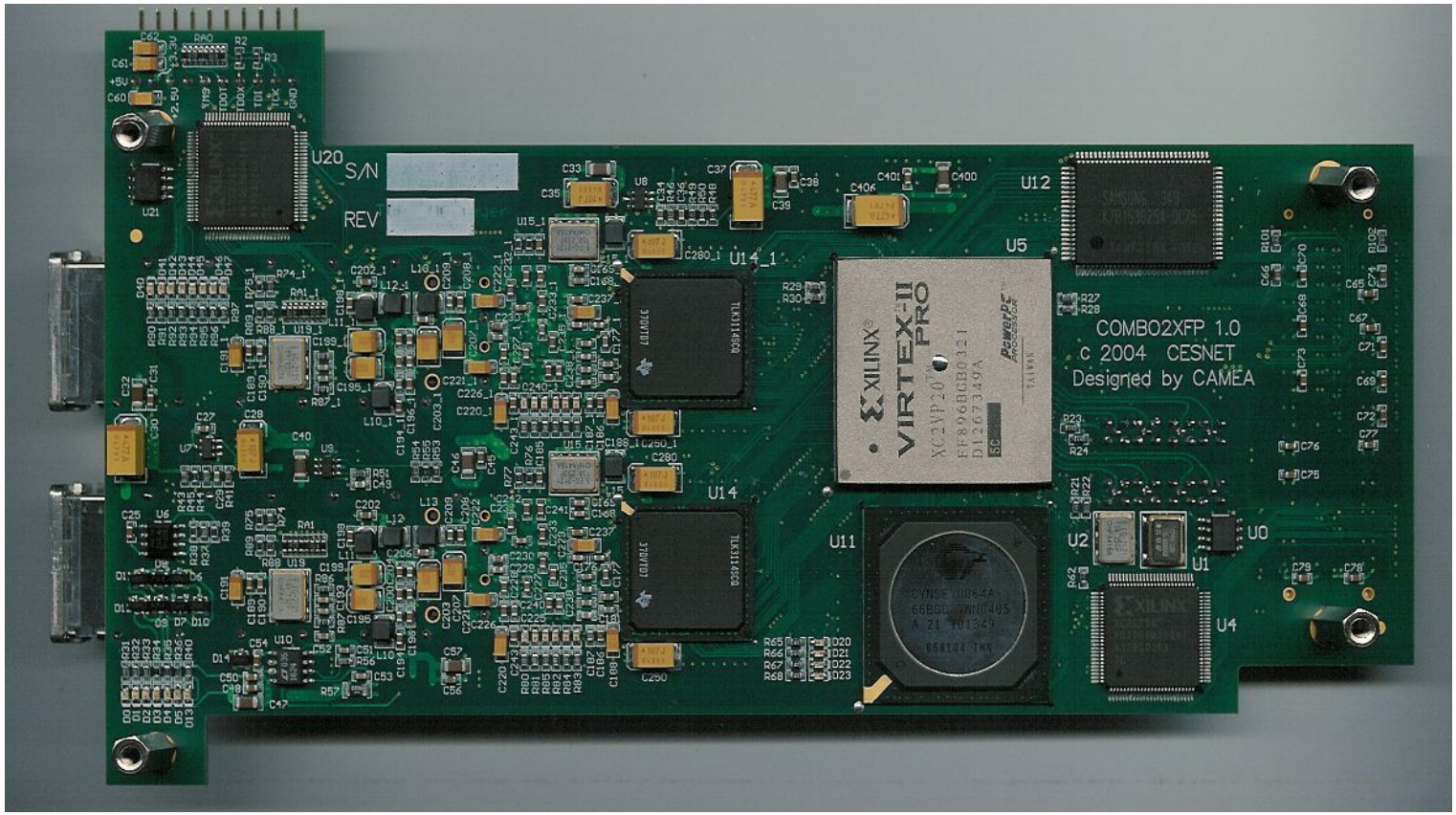
COMBO-4SFP

Interface card with 4x1Gb/s optical ports

- 2xXILINX FPGA (VIRTEX II 1000-3000)
- 2xSRAM, 3xEEPROM
- 4x1Gb ports in SFP cages (hot swap)
- hw supports four speeds - 1GbE, Infiniband, Fiber channel

Status - fully operational

COMBO-2XFP


U20
S/N
REV
U12
U5
U14
U11
U2
U1
U0
U4
XILINX
VIRTEX-II PRO
COMBO2XFP 1.0
c 2004 CESNET
Designed by CAMEA

COMBO-2XFP

Interface card with 2x10Gb/s optical ports

- 1xXILINX FPGA (VIRTEX II PRO XC2VP20), Power PC inside
- 1xSRAM, 1xCAM, 3xEEPROM
- 2x10Gb ports in XFP cages (hot swap)

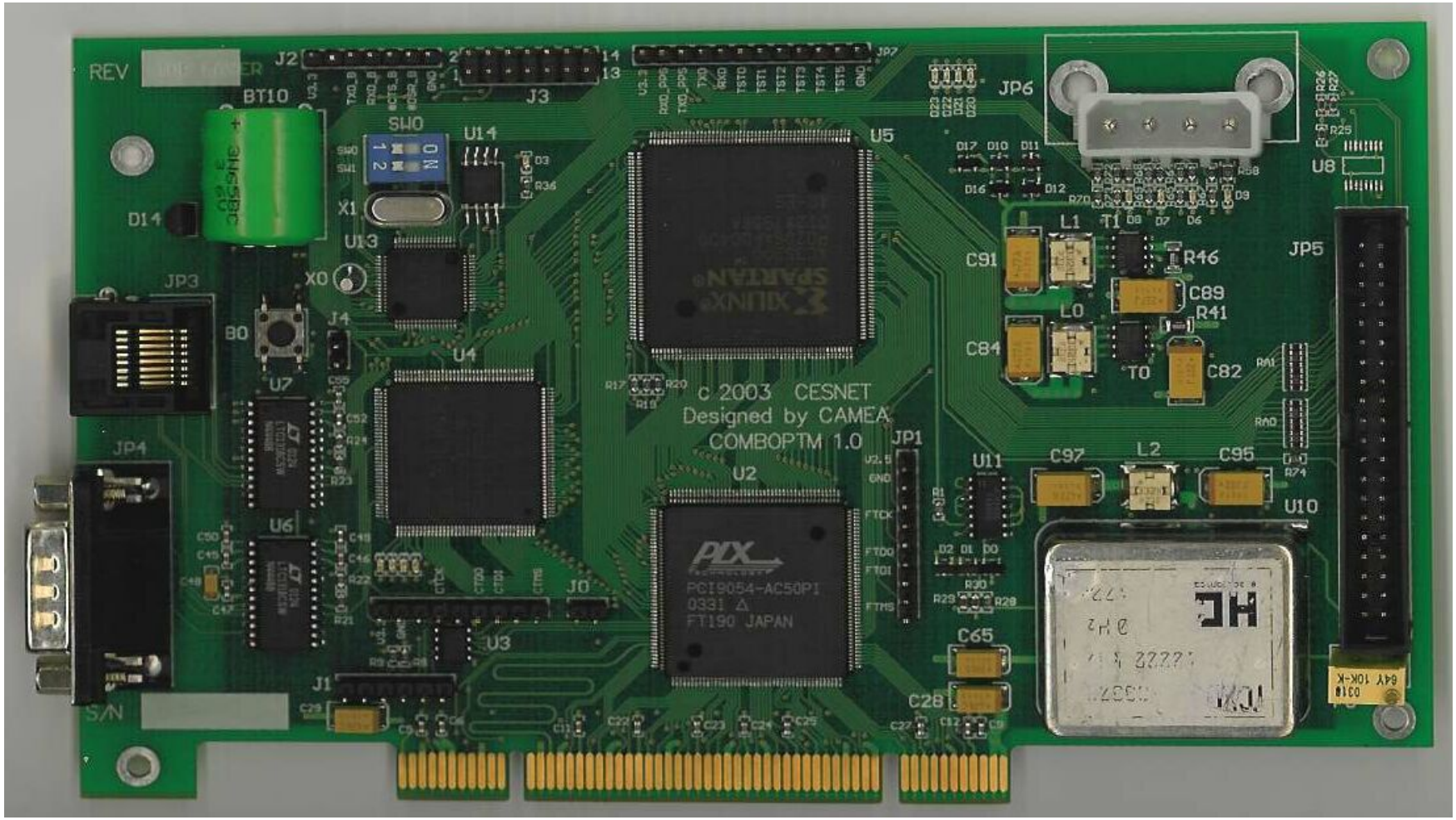
Status - operational (but need to be redesigned, issues with phyters)

COMBO-2XFPRO, COMBO-4SFPRO

New generation of interface cards

- Based on XILINX VIRTEX II PRO and VIRTEX II PRO-X
- No phyters
- COMBO-4SFPRO - 4x1GbE (VIRTEX II PRO), 4xOC48 (VIRTEX II PRO-X)
- COMBO-2XFPRO - 2x10GbE or 2xOC192
- Status - in design phase

COMBO-PTM


REV
J2
J3
BT10
SW0
U14
U5
JP6
D14
X1
U13
U8
JP5
JP3
X0
B0
J4
U4
U7
C91
L1
T1
R46
C89
R41
L0
C84
T0
C82
c 2003 CESNET
Designed by CAMEA
COMBOPTM 1.0
JP1
U2
U11
C97
L2
C95
U10
JP4
U6
PCI9054-AC50PI
0331 Δ
FT190 JAPAN
J0
U3
C65
J1
C28
S/N

COMBO-PTM

Precise Time Module

- XILINX FPGA (Spartan 3) - 90nm technology
- MCU - Texas Instruments MSP430FI49IPM
- Precise crystal
- Connector for GPS (PPM, data)

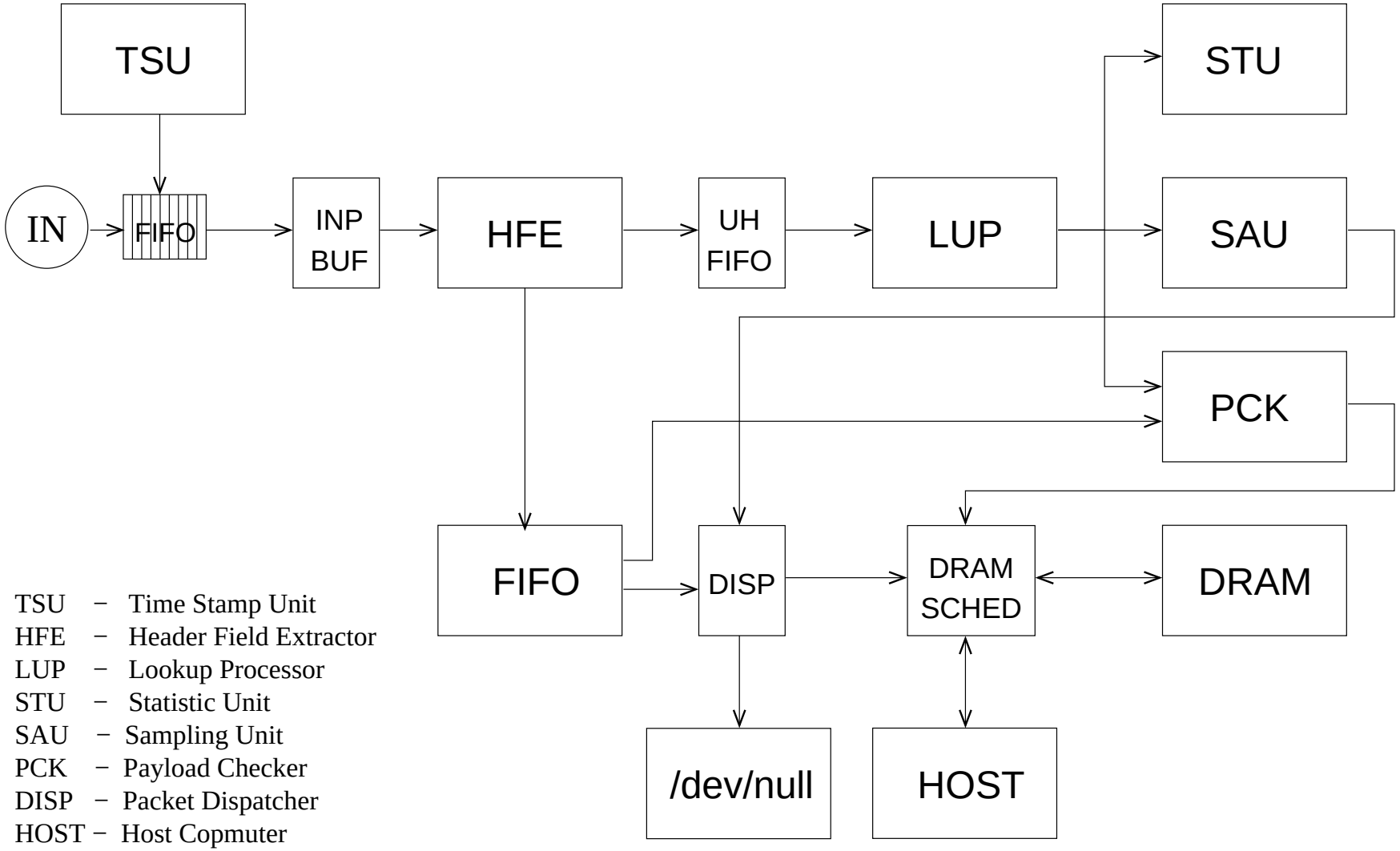
Status - fully operational

SCAMPI adapters

- SCAMPI-4MTX -> COMB06, COMBO-4MTX, COMBO-PTM
- SCAMPI-4SFP -> COMB06, COMBO-4SFP, COMBO-PTM, 4xSFP transceiver
- SCAMPI-2XFP -> COMB06X, COMBO-2XFP, COMBO-PTM, 2xXFP transceiver
- Any combination of COMBO6, COMBO6X with, COMBO-4MTX, COMBO-4SFP, COMBO-2XFP, COMBO-2XFPRO, COMBO-4SFPRO is available

SCAMPI Firmware

- Modular design
- VHDL-standard development approach with simulation
- Nanoprocessors instead of FSMs
- Prototyping firmware blocks in SW
- Hardware/software co-design



TSU − Time Stamp Unit
HFE − Header Field Extractor
LUP − Lookup Processor
STU − Statistic Unit
SAU − Sampling Unit
PCK − Payload Checker
DISP − Packet Dispatcher
HOST − Host Copmuter

VHDL blocks

Time Stamp Unit (TSU)

- 64 bits fixed point - 32 number of seconds (since 1.1.1970), 32 fraction of second
- resolution 10 ns (64 bytes at rate 10Gb/s ~ 50 ns)
- controlled by PPS input (e.g. GPS receiver), accuracy (with PPS) ~ 1 us, accuracy (with NTP) ~ 50 us

Packet classification

- Header Field Extractor (HFE) - extract information for classification from packet headers

- Look-up Processor (LUP) - packet classification

  CAM - matching up 272 bits

  processing unit - search tree

Sampling Unit (SAU)

- deterministic sampling - each n-th packet is passing through
- byte deterministic - each packet containing n-th byte is passing through
- probabilistic sampling - packet is passing with probability 1/n

STU (statistic unit)

- packets lengths statistic: number of packets, total length, sum of squares od lengths, min/max value
- statistics of intervals between packets: number of packets, total time, sum of squares of intervals, min/max

PCK (payload checker)

- CAM is used for payload checking
- checks payload for defined patterns (16 bytes)

SCAMPI SOFTWARE

- Linux driver
- Mapi for COMBO6
- Software simulator of COMBO6 on top of commodity card
- Comfort development environment for nanoprograms (nsim)
- Comboctl - loader and comfort debugging

More information can be found at

`http://www.liberouter.org/`