

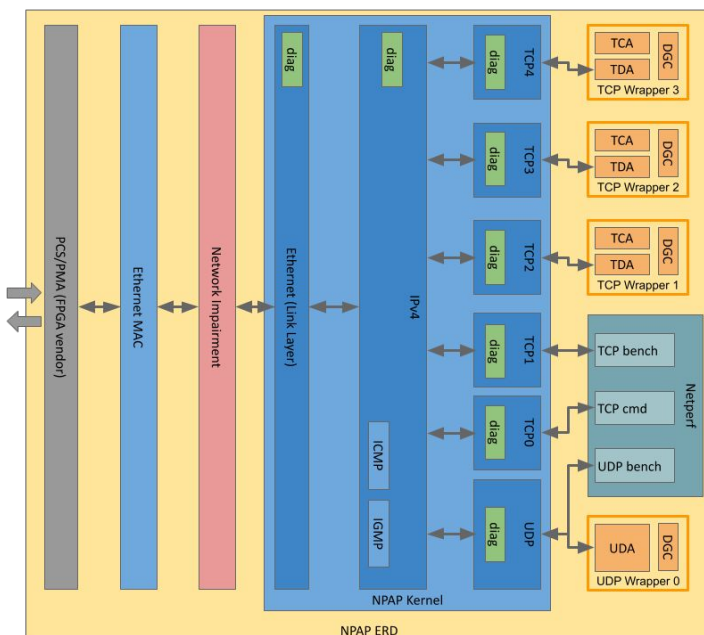
MLE has optimized for Altera Agilex-5 and Agilex-7 devices the industry proven TCP/UDP/IPv4 Network Protocol Acceleration Platform (NPAP). Originally developed by Fraunhofer HHI, NPAP implements fast and reliable networking solutions for high-bandwidth, low-latency Multi- Gigabit Ethernet.

## Application Use Cases

- Full TCP/UDP/IPv4 connectivity for FPGAs
- High-speed sensor DAQ: Stream data from FPGA into Network-Attached Storage (NAS)
- High-speed robotics control: Stream data from servers via FPGA into actuators
- High-bandwidth, low-latency automotive ECU-to-ECU connectivity e.g. for SOME/IP
- SmartNIC using TCP/IPV4 "Full Acceleration"
- Hyper-converged computational storage acceleration, for "over-Fabric" NVMe/TCP
- Deterministic low-latency, high-bandwidth alternative to lwIP or Linux on embedded CPU

## Dataflow Block Diagram

- Many dedicated TCP Cores
- Single UDP Core
- Netperf Bandwidth, Latency Benchmark
- Network Impairment / BERT (optional)
- Network Diagnostics (optional)



## Key Features

- Highly modular TCP/UDP/IPv4 Stack implementation for MAC, Ethernet, IPv4, TCP, UDP processing implemented in synthesizable HDL
- Bi-directional 128-bit data streams to deliver line rates up to 70 Gbps (depends on FPGA speed)
- Multiple, parallel TCP engines (sockets) for predictable scalable processing
- Network Interface Card (NIC) with optional Bypass and PCIe DMA
- Point-to-point of LAN capable
- Tested for interoperability with TCP/UDP/IPv4 from Linux, Microsoft Windows, SolarFlare, Mellanox
- User applications for payload processing either in programmable logic or in software via PL/PS datamovers
- Resource analysis for full stack including UDP plus 2 TCP ~30k LEs, +10k LEs for each additional TCP engine

## Deliverables

- As IP Core or customized FPGA subsystem
- Single-Project-Use Netlist (or equiv.)
- Multi-Project-Use Source Code
- Customized, integrated turnkey solutions
- Application-specific expert design services

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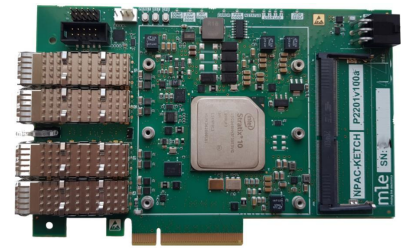


## Exemplary Evaluation Reference Designs (ERD)

- Full network stack, including low-latency MAC
- TCP/UDP Netperf/Netserv (interops w/ open-source Netperf/Netserv V2.6)
- TCP Loopback and UDP Loopback
- Stack control software (for IP addresses, etc)

## MLE NPAC-40G SmartNIC Solution

- 10 GigE with 9.8 Gbps linerate
- Integrated with Intel/Altera 10G/25G Ethernet FPGA IP
- SFP+ for 4x 10 GigE via Twinax or Fibre
- Based on Intel/Altera Stratix 10 GX 400



▲ MLE NPAC-40G SmartNIC Solution

## Altera Agilex-7 on Silicom ThunderFjord Card

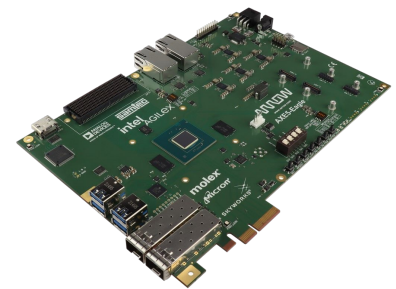
- Agilex<sup>®</sup> 7 FPGA AGM032 / AGM039
- 2 x QSFPDD56 ports (50GigE)
- HBM2e options: 32GB, 16BG, No HBM2e
- DDR5 option: 4GB DDR5 ECC RAM (available to HPS)
- PCIe x16 Gen5
- Dual slot passive heat sink (single slot option on request)



▲ Altera Agilex-7 on Silicom ThunderFjord

## Arrow AXE5-Eagle Development Kit

- 10 GigE with 9.8 Gbps linerate
- Integrated with Intel/Altera 10G/25G Ethernet FPGA IP
- SFP+ for 2x 10 GigE via Twinax or Fibre
- Based on Intel/Altera Agilex 5 E-series FPGA



▲ Arrow AXE5-Eagle Development Kit

## Fraunhofer Heinrich-Hertz-Institute (HHI)

Founded in 1949, the German Fraunhofer-Gesellschaft undertakes applied research of direct utility to private and public enterprise and of wide benefit to society. With a workforce of over 23,000, the Fraunhofer-Gesellschaft is Europe's biggest organization for applied research, and currently operates a total of 67 institutes and research units. The organization's core task is to carry out research of practical utility in close cooperation with its customers from industry and the public sector.

Fraunhofer HHI was founded in 1928 and joined in 2003 the Fraunhofer-Gesellschaft as the "Fraunhofer Institute for Telecommunications, Heinrich-Hertz-Institut,," Today it is the leading research institute for networking and telecommunications technology, "Driving the Gigabit Society" .

## Missing Link Electronics (MLE)

We are a Silicon Valley based technology company with offices in Germany. We are partner to leading electronic device and solution providers and have been enabling key innovators in the automotive, defense, industrial, medical, test & measurement markets with FPGA-based subsystems and systems.

Our mission is to offload CPUs and accelerate software-rich system stacks via so-called Domain-Specific Architectures. To implement this we make heavy use of heterogeneous processing such as FPGAs which we program using C++/C/SystemC as well as VHDL and Verilog HDL.

Our expertise is to "proudly source elsewhere" which means rather than re-inventing the wheel we license (and sublicense) 3rd party IP cores from our growing list of partners and combine this with Open Source Software like Linux to deliver Full System Stacks for FPGA. Today, we offer high-performance (embedded) compute, image-processing, storage and network systems and solutions as well as licensable system stacks for adaptable compute platforms.