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Directions for COIN

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Intention

- **In-network computing can be conceived in many different ways**
 - active networking
 - data plane programmability
 - running virtualized functions
 - service chaining
 - distributed computing.
- **This draft**
 - proposes a particular direction for COIN research
 - lists suggested research challenges

This Draft

Different types of in-network
computing systems

Examples

Terminology

Research Challenges

Characterizing Computing in the
Network vs. Packet Processing &
Networked Computing

Different Types of In-Network Computing Systems

1. Active Networking
2. Edge Computing
3. Dataplane programmability
4. Application-layer data processing frameworks
5. Service Function Chaining

Computing in the Network vs Networked Computing vs Packet Processing

- **Networked Computing**
 - use networking to connect compute instances
 - VMs, microservice instances
 - interaction types such as RPC, REST
 - applications such as CDN
 - not really “computing in the network” – just connected computing
- **Packet Processing**
 - transparent middleboxes applying processing functions on packets
 - typically not very programmable
- **Active networking**
 - offering abstraction for programming packet processing from an endpoint perspective

Computing in the Network vs Networked Computing vs Packet Processing

- **Programmable Data Plane**

- abstractions of different types of network switch hardware (NPUs, CPUs, FPGA, PISA) from a switch/network programming perspective.
- programs are constrained by the capabilities (instruction set, memory) of the target platform
- typically operate on packets/flow abstractions (for example *match-action-style processing*)

- **Network Functions Virtualization**

- networked computing applied to telco functions
- some VNFs happen to process/forward packets
- packet steering could be programmed through SDN

Computing in the Network vs Networked Computing vs Packet Processing

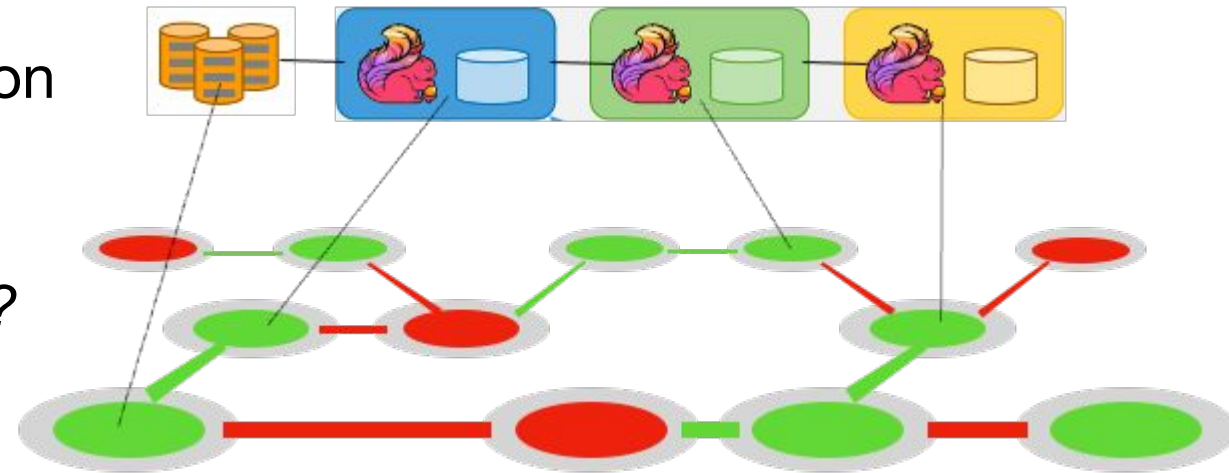
- **Service Function Chaining**
 - more dynamic way for traffic steering
 - dynamic chain of IP-addressable packet processors
 - implemented by encapsulation

Computing in the Network vs Networked Computing vs Packet Processing

- Sometimes, networked computing and packet processing go well together
 - for example, when network virtualization is achieved through data-plane programming (SDN-style) to provide connectivity for VMs
 - MEC and network slicing could be an example
- Not really computing *in* the network though

Computing in the Network vs Networked Computing vs Packet Processing

- **Application layer distributed computing**
 - Spark, Storm, Flink
 - Could benefit from better integration in the network
- *How could the network support such distributed computing systems better?*
 - We discuss this a resource allocation problem
 - “joint optimization of computing, networking, caching”



Examples

- **Compute-First Networking in ICN**
 - Turing complete decentralized distributed computing framework
 - Python programmable
 - Shared compute graph and resource status via dataset synchronization in ICN
- **Akka Toolkit**
 - Actor model: asynchronous message-based communication between processes encapsulating application logic
- **Distributed stream processing**
 - More structured distributed computing (typically DAG)
 - Stateful or stateless data-driven computation
- **Distributed machine learning**
 - dividing training jobs across multiple processors
 - different aggregation / collection functions

Research Challenges

1. Categorization of Different Use Cases for Computing in the Network
2. Modeling Distributed Computing
3. Mapping Computing Semantics to Infrastructure
4. Networking and Remote-Method-Invocation Abstractions
5. Transport Abstractions
6. Programming Abstractions
7. Security, Privacy, Trust Model
8. Orchestration and Coordination
9. Fault Tolerance, Failure Handling, Debugging, Management

Next Steps

- Want to address Collective Communications better
 - we already talk about machine learning, but could be more specific
 - also talk about how generic aggregation functions in the network can help
 - discuss transport for Collective Communication
- Want to articulate research challenge better
 - be more specific about new challenges with COIN relevance

- Maturity level: will probably need a few iterations – please send suggestions!