ERLANG DISTRIBUTION

GOING BEYOND THE FULLY CONNECTED MESH

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LIGHTKONE

Lightweight computation for networks at the edge

Funded by the Horizon 2020 Framework Programme of the European Union

- Computation at the Edge
- CRDTs
- Gossip protocols

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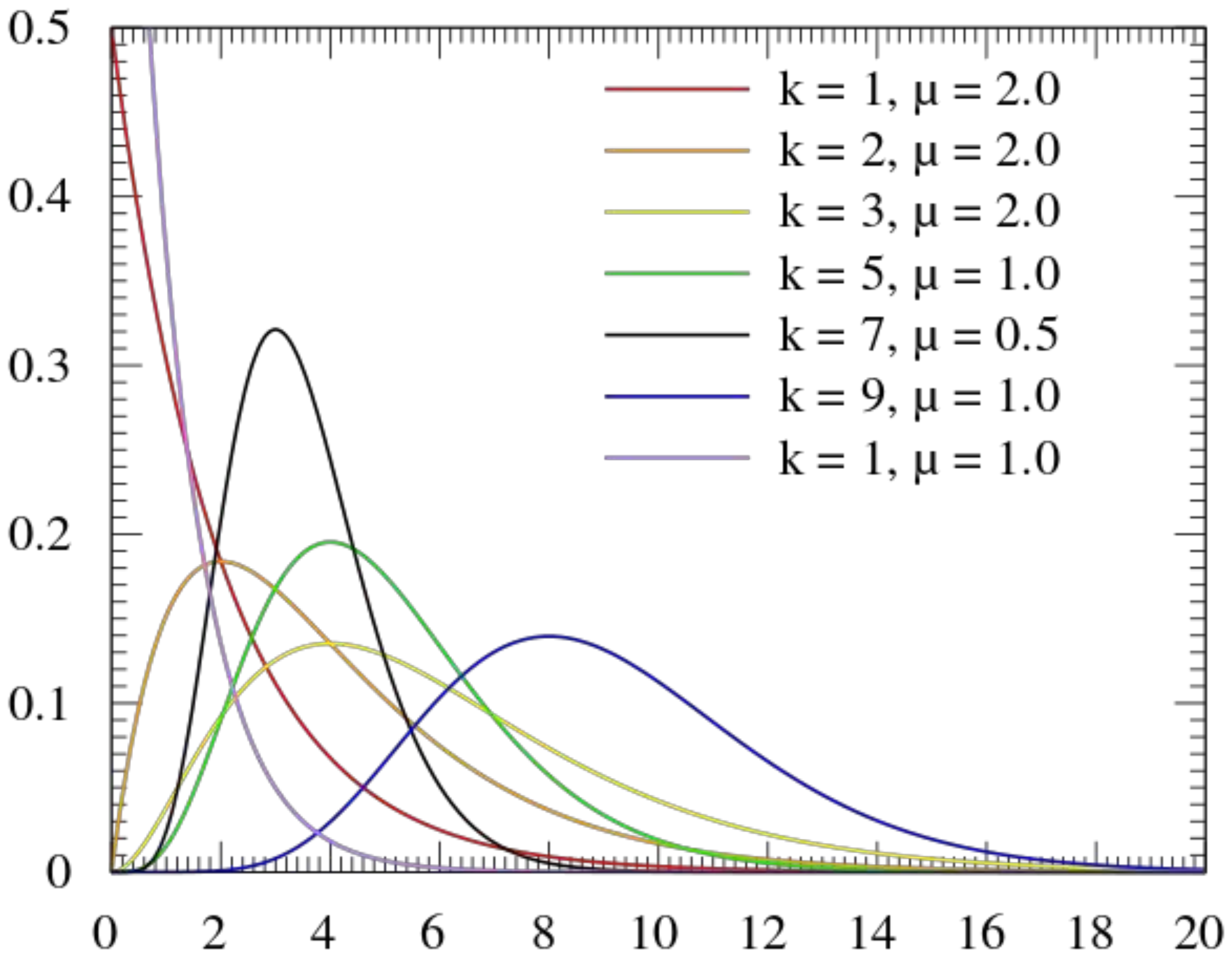
ERLANG DISTRIBUTION

$$f(x;k,\mu) = \frac{x^{k-1} e^{-\frac{x}{\mu}}}{\mu^k (k-1)!} \quad \text{for } x, \mu \geq 0.$$



ERLANG DISTRIBUTION

- Transparent distribution protocol
- Send Messages
- Link Processes
- Monitor Processes

PROBLEMS

- Default is fully connected mesh
- Fully connected mesh doesn't scale well
  - Hidden nodes can help, but is not a solution
- Global process registry requires fully connected mesh

UDP DISTRIBUTION PROTOTYPE

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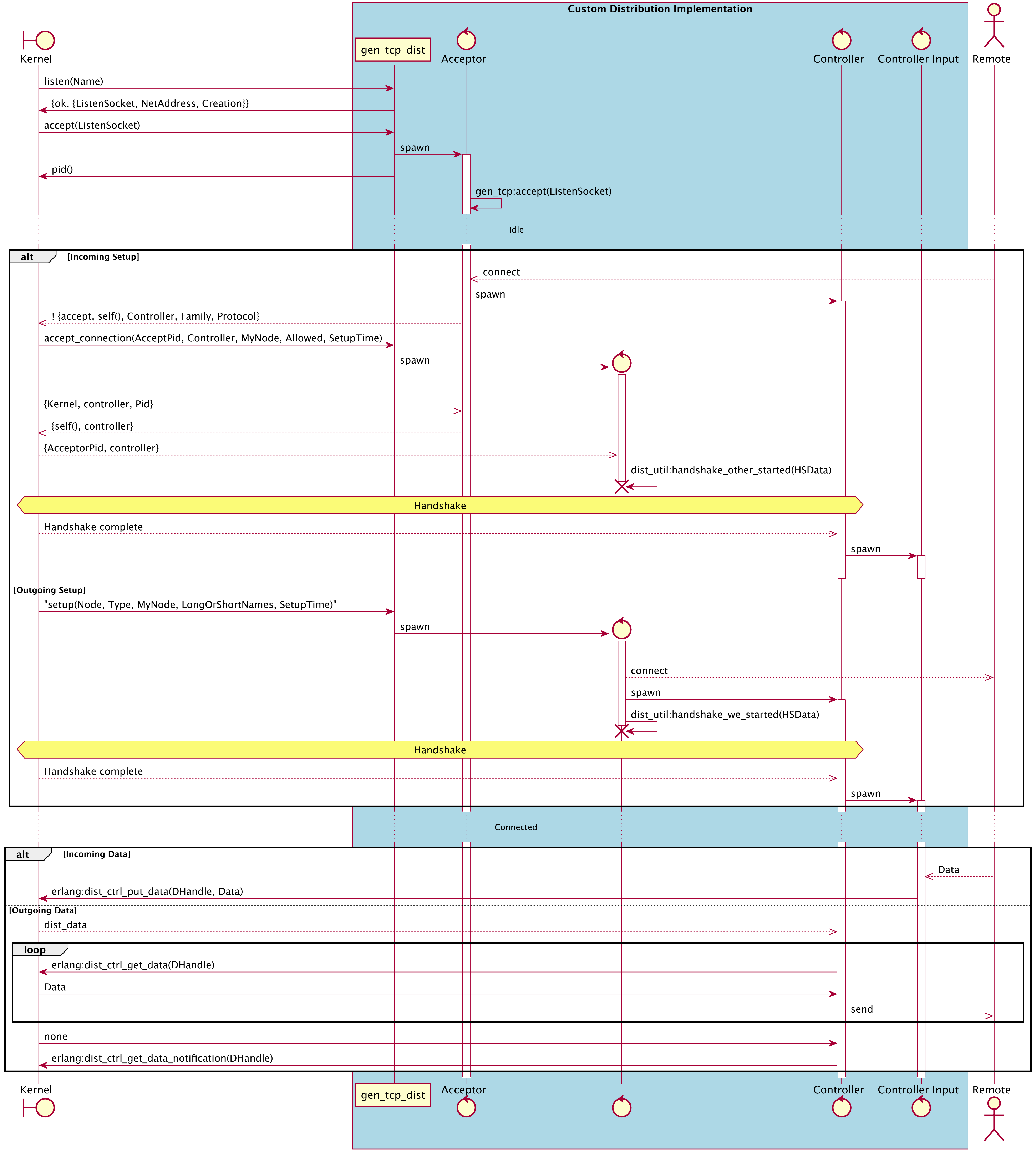
IMPLEMENTATION

- Started out based on our work on working around head-of-line blocking
    - Alternative ways to avoid the problem
- Stepping stone towards experience with building multiple distribution implementations
- Learn how to support less connection oriented ways of implementing distribution

Uh...



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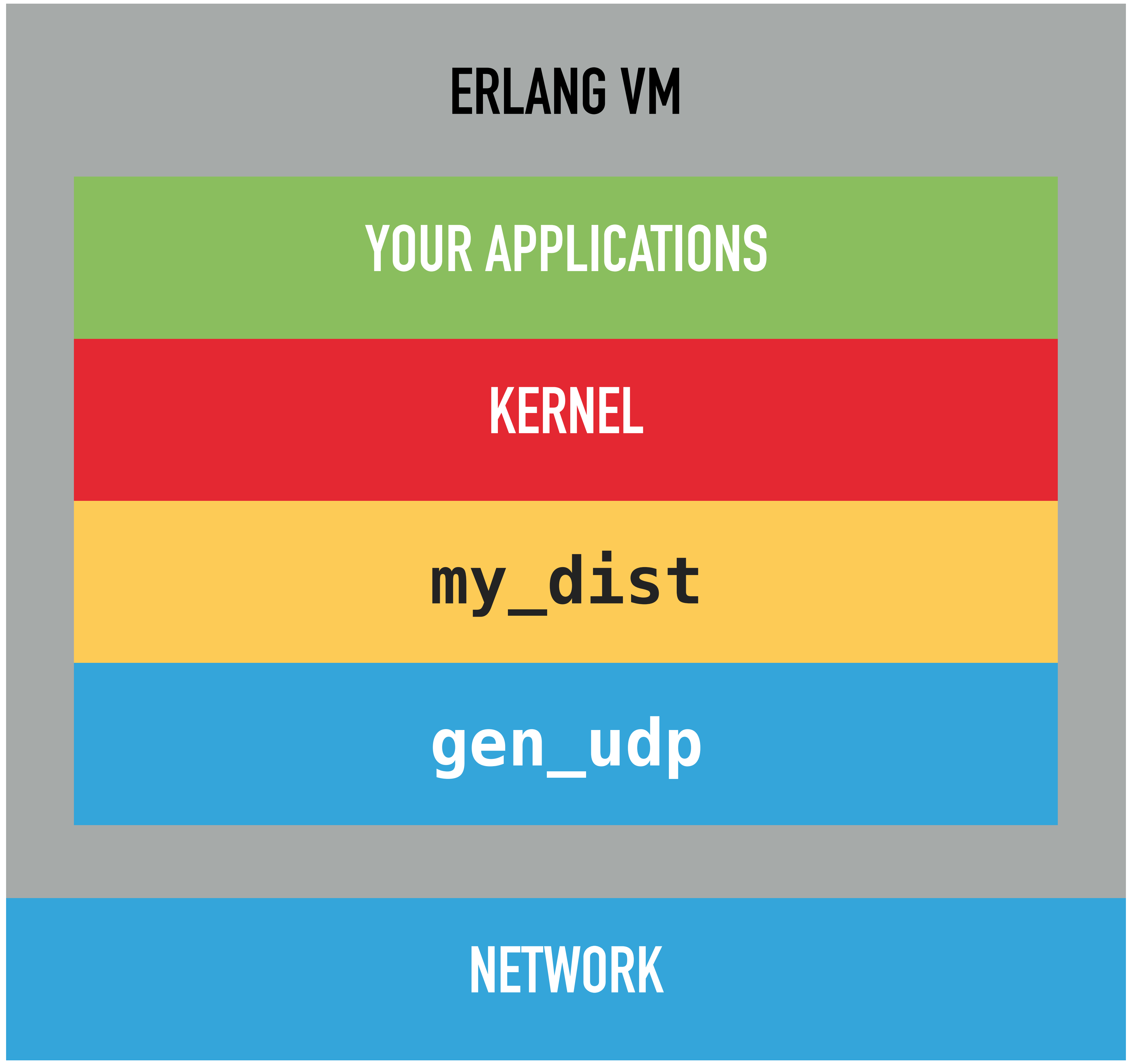
THE DISTRIBUTION “STACK”



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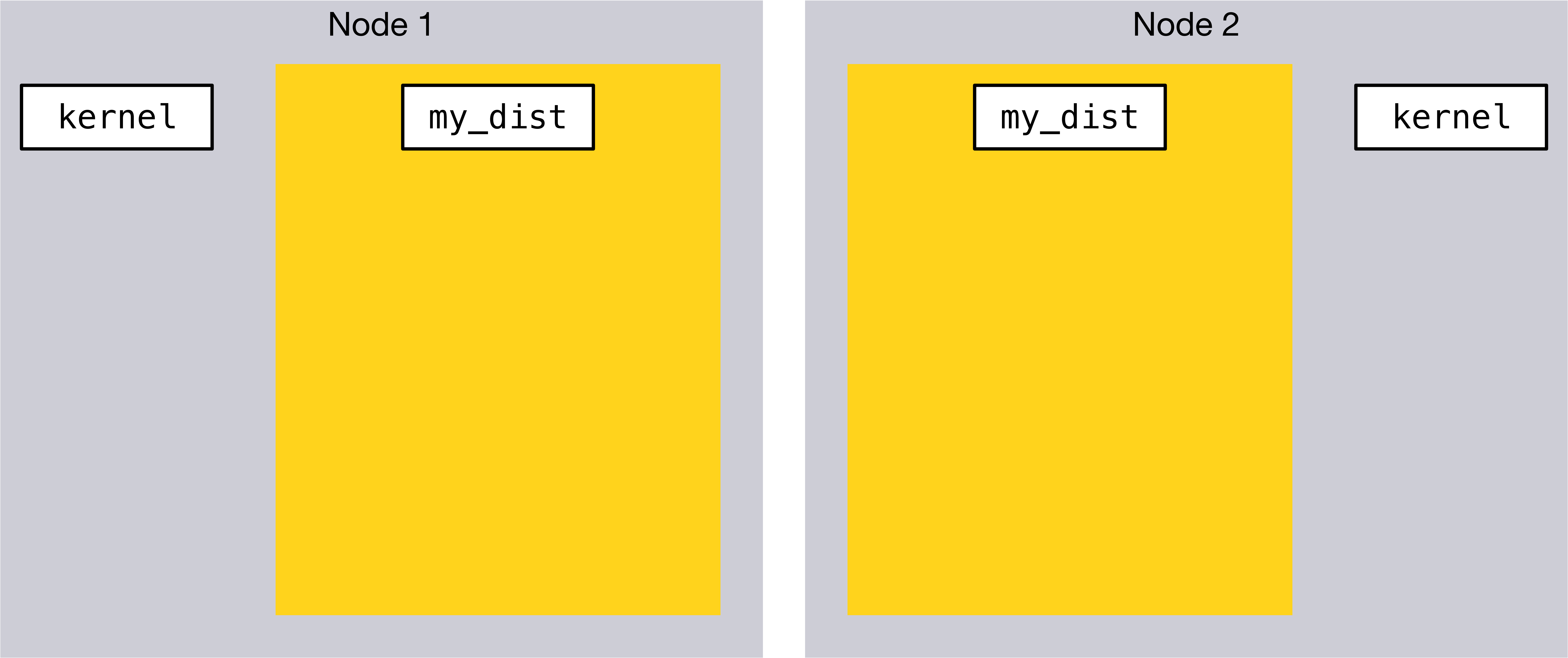
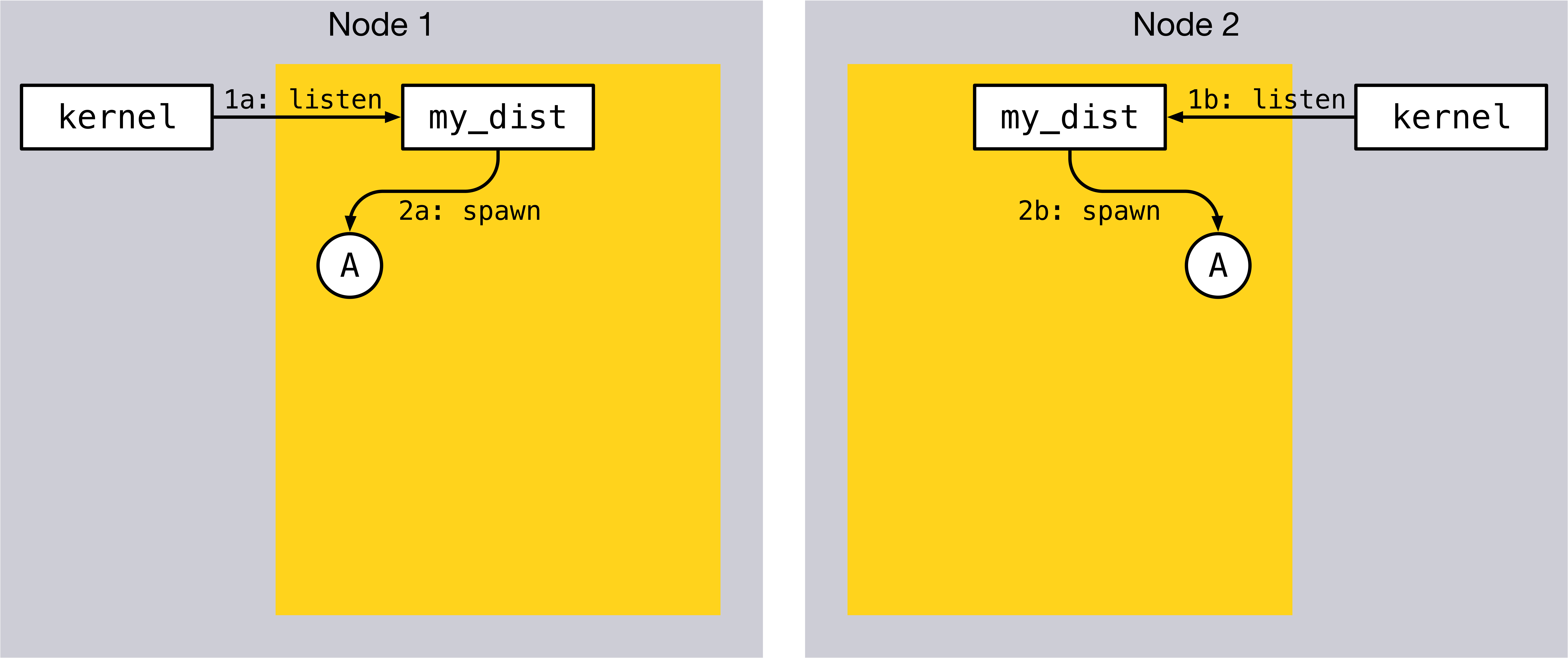
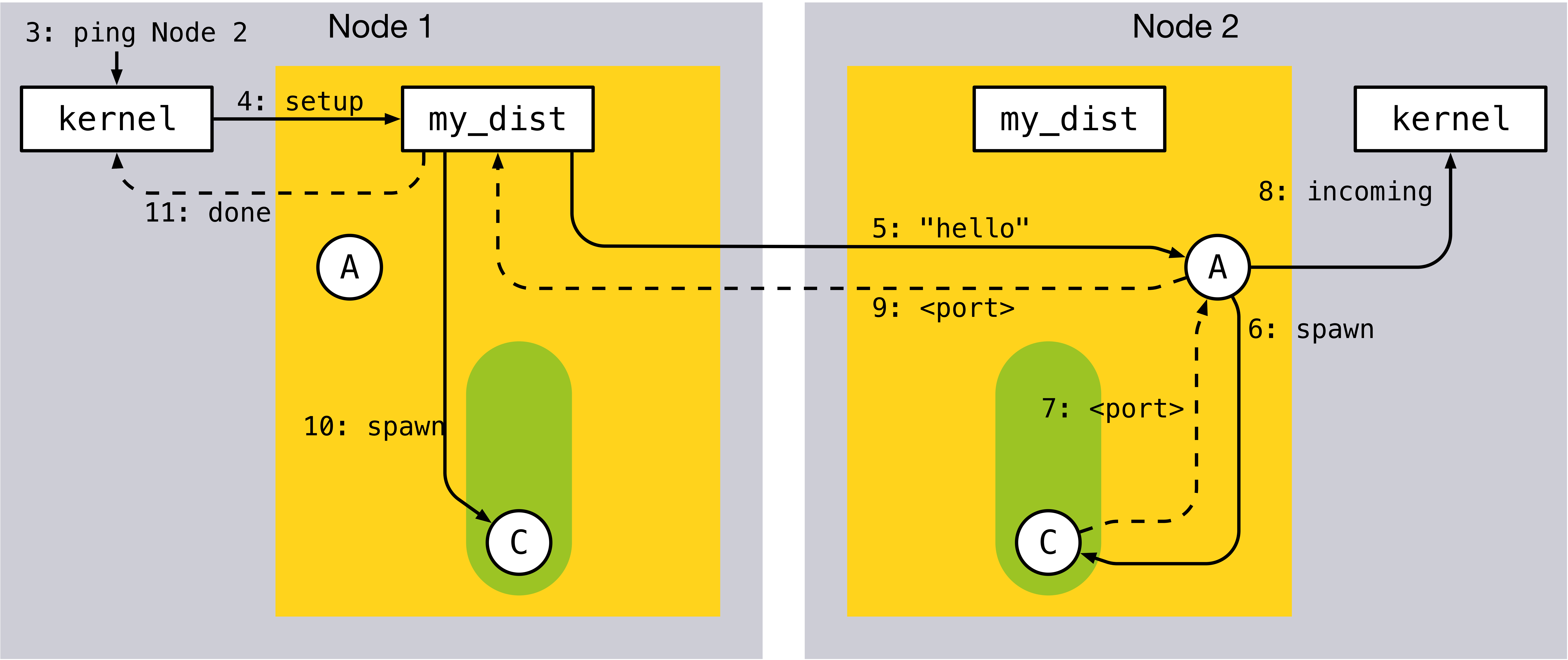
UDP DISTRIBUTION PROTOTYPE



UDP DISTRIBUTION PROTOTYPE



UDP DISTRIBUTION PROTOTYPE



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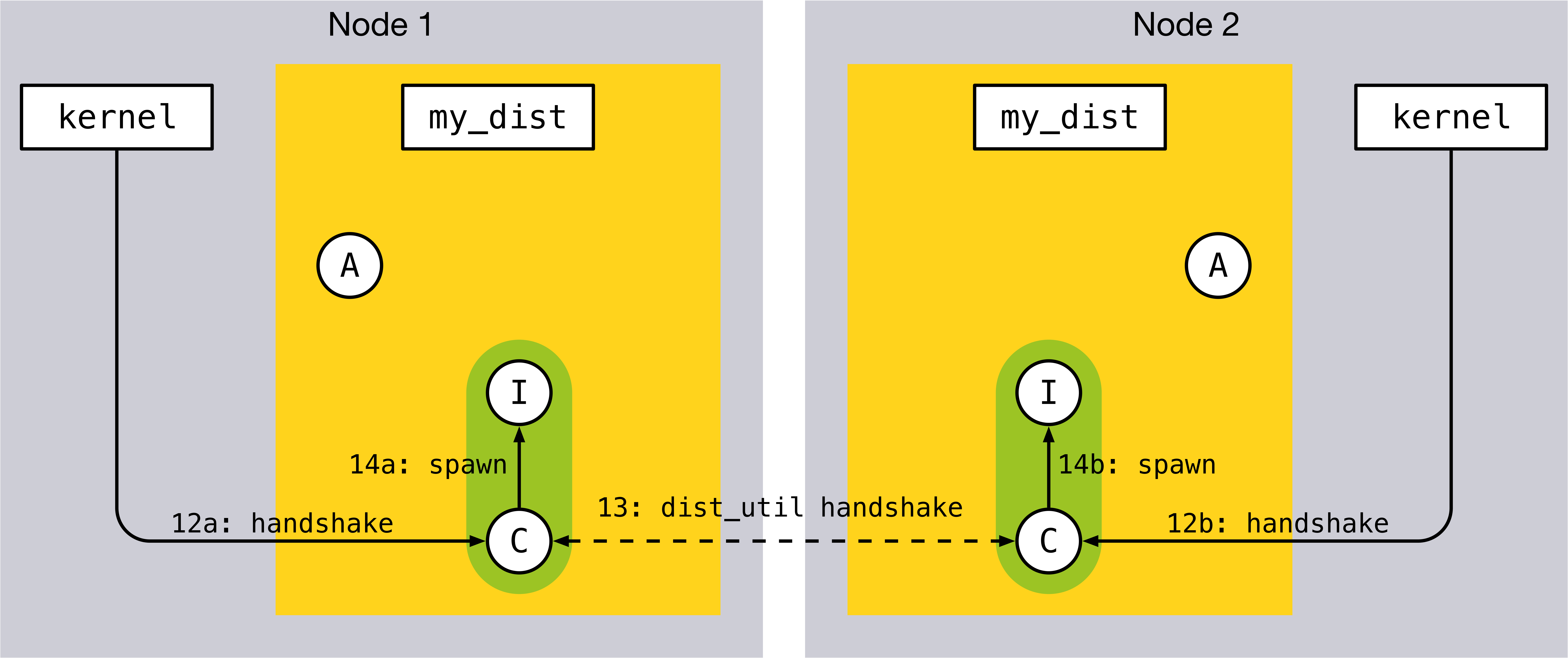
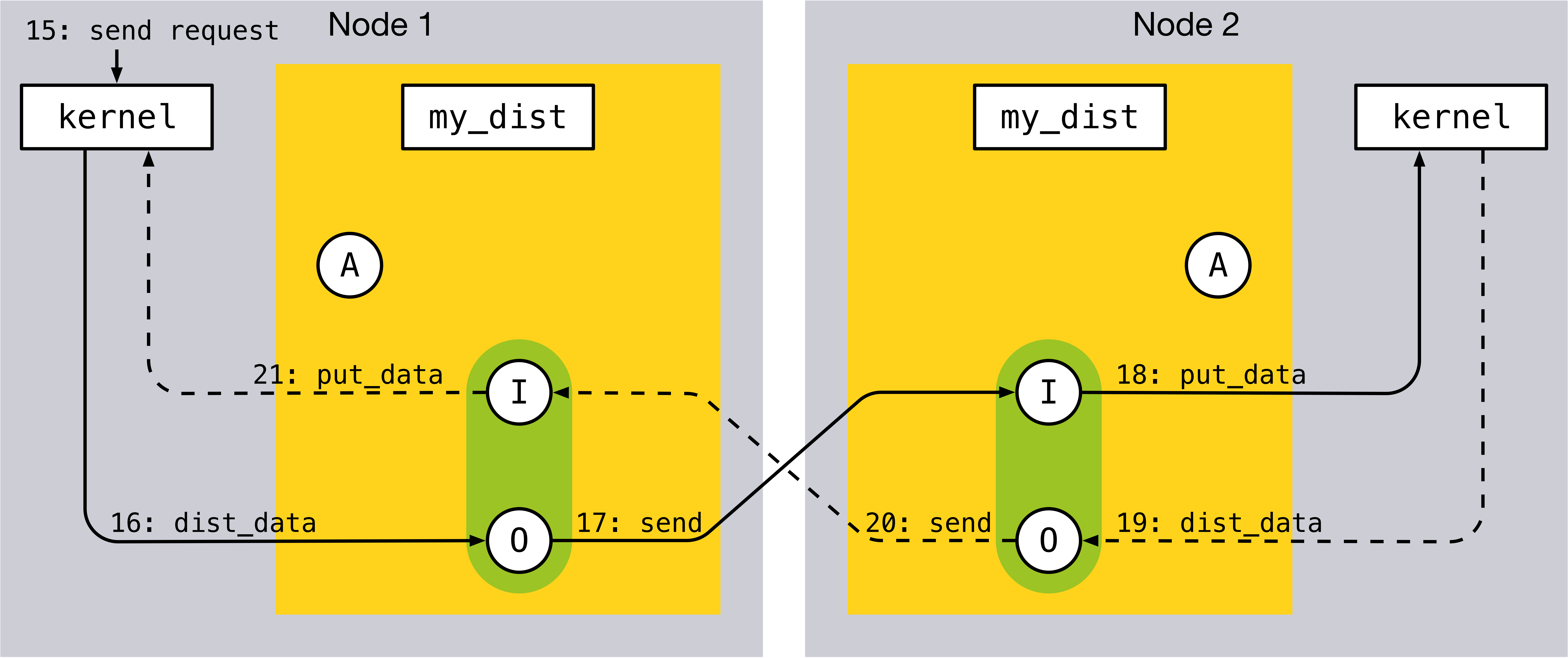

Node 1
Node 2
kernel
my_dist
A
I
C
14a: spawn
12a: handshake
13: dist_util handshake
my_dist
kernel
A
I
C
14b: spawn
12b: handshake

UDP DISTRIBUTION PROTOTYPE



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UDP DISTRIBUTION PROTOTYPE SUMMARY

- One acceptor process per node
  - Opens a separate UDP listening port for connection attempts
- Two processes, one input and one output, per node connection
  - Could have been one process, but better throughput this way
- (not shown) Erlang Port Mapping Daemon (epmd) used to get the initial acceptor port to connect to

DEMO

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NEXT STEPS

GENERIC DISTRIBUTION BEHAVIOR

A DISTRIBUTION BEHAVIOR

- The UDP prototype is quite similar to the TCP example from OTP
- What if we could make a behavior that encapsulates all the complexity of the current API and process model?
  - What would such a behavior look like?
  - What are the valid process models?
  - Can we combine this with a pluggable transport layer as well?

CURRENT STATE

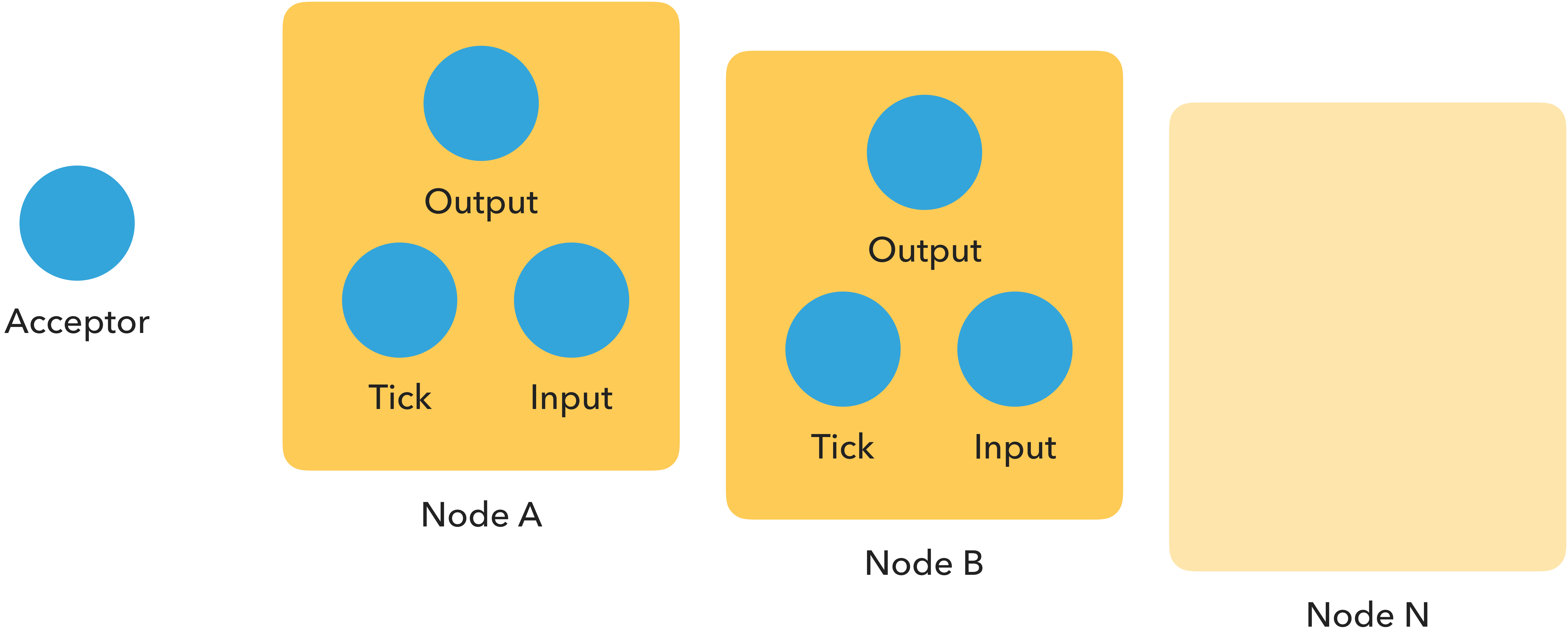
- Custom distribution API exposed in OTP 20
- API is based on the internal implementation for TCP

CHALLENGES USING THE LOW-LEVEL OTP API

- Distribution starts early, even before the IO server
  - No supervision, errors sometimes hidden or hard to expose
- The API surface is fragmented
  - callbacks
  - calls
  - message passing

PROCESS MODEL

- TCP example uses 1 process for listening and 3 processes per node connection



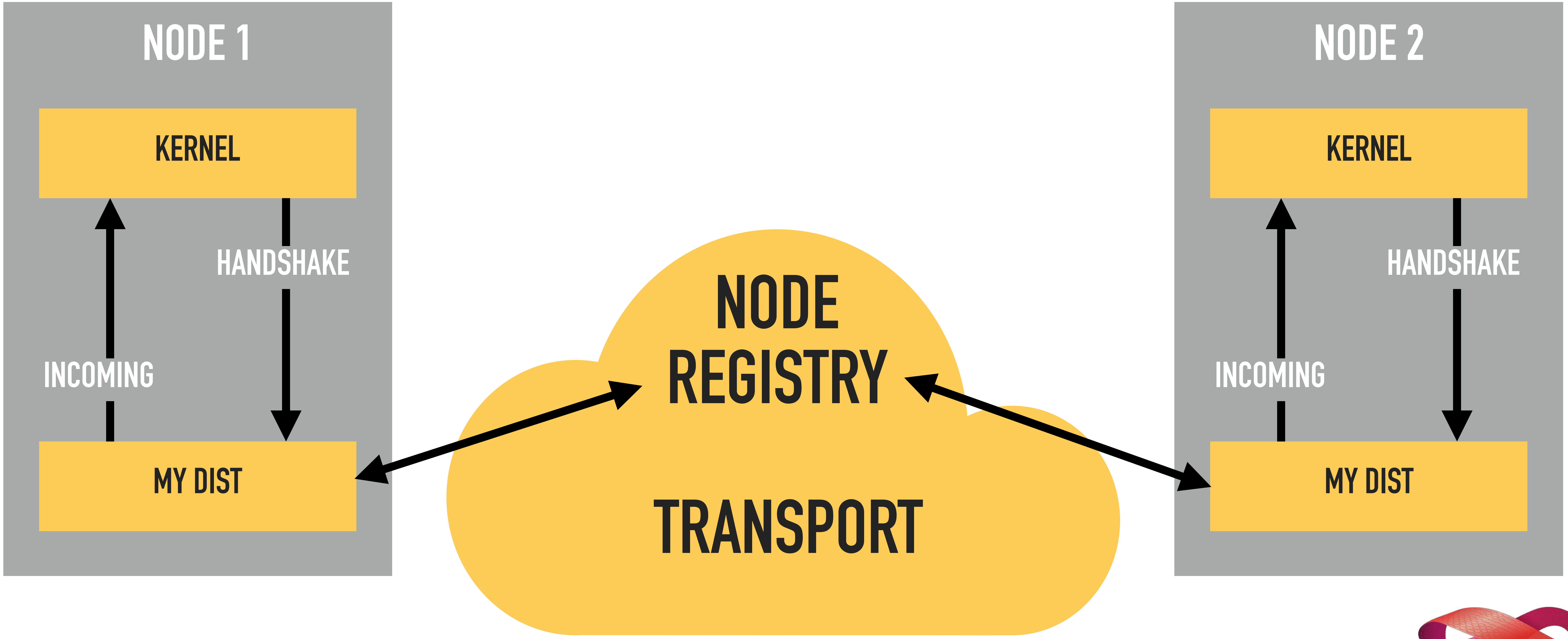
PROCESS MODEL

- Custom transport may require 0-N processes for listening and 0-N processes for connections
- Unsolved problem: generic callback behavior for running a dynamic number of processes with unique roles
- **Plan of attack:** Stick with the 1-3 model for now, experiment with other models later

API PROPOSAL

- Acceptor
  - acceptor_init/0
  - acceptor_info/2
  - acceptor_controller_spawned/3
  - acceptor_terminate/1
- Output
  - output_init/1
  - output_send/2
- Input
  - input_init/1
  - input_info/2
- Tick
  - tick_init/1
  - tick_trigger/2

HIGH LEVEL APPROACH



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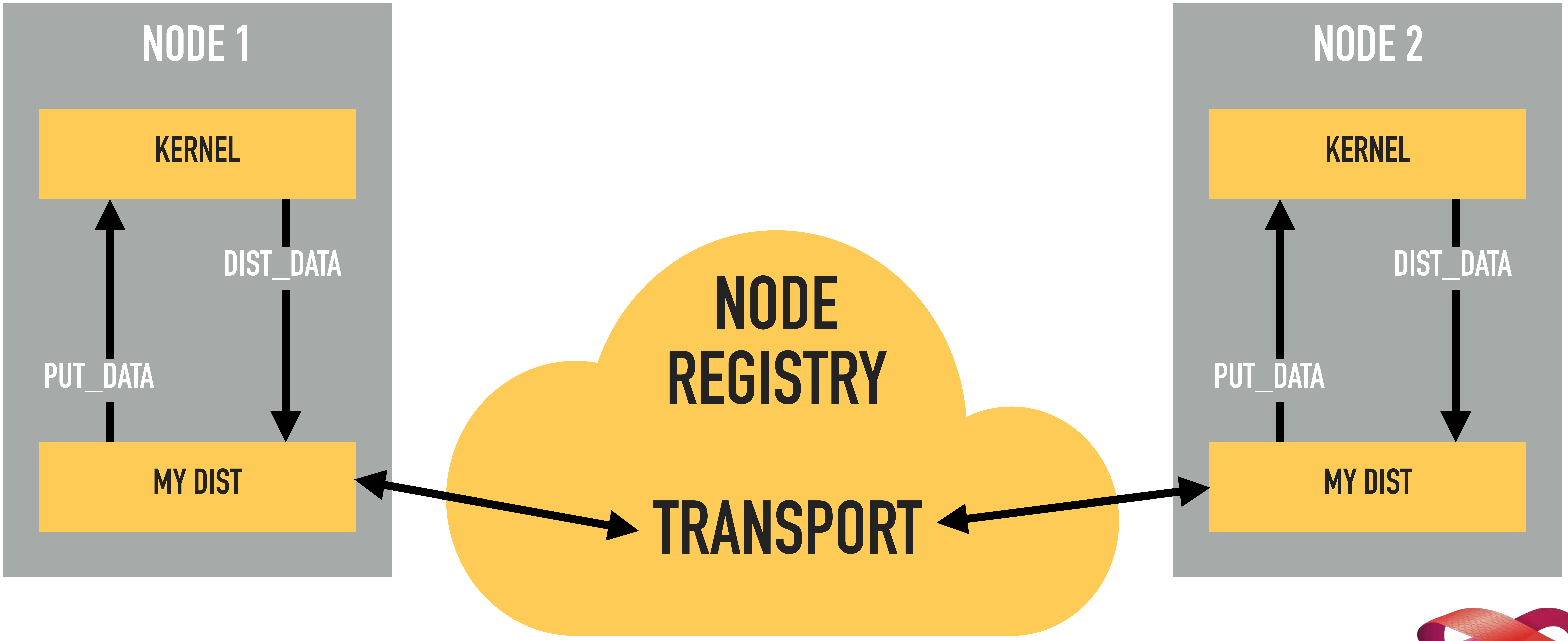
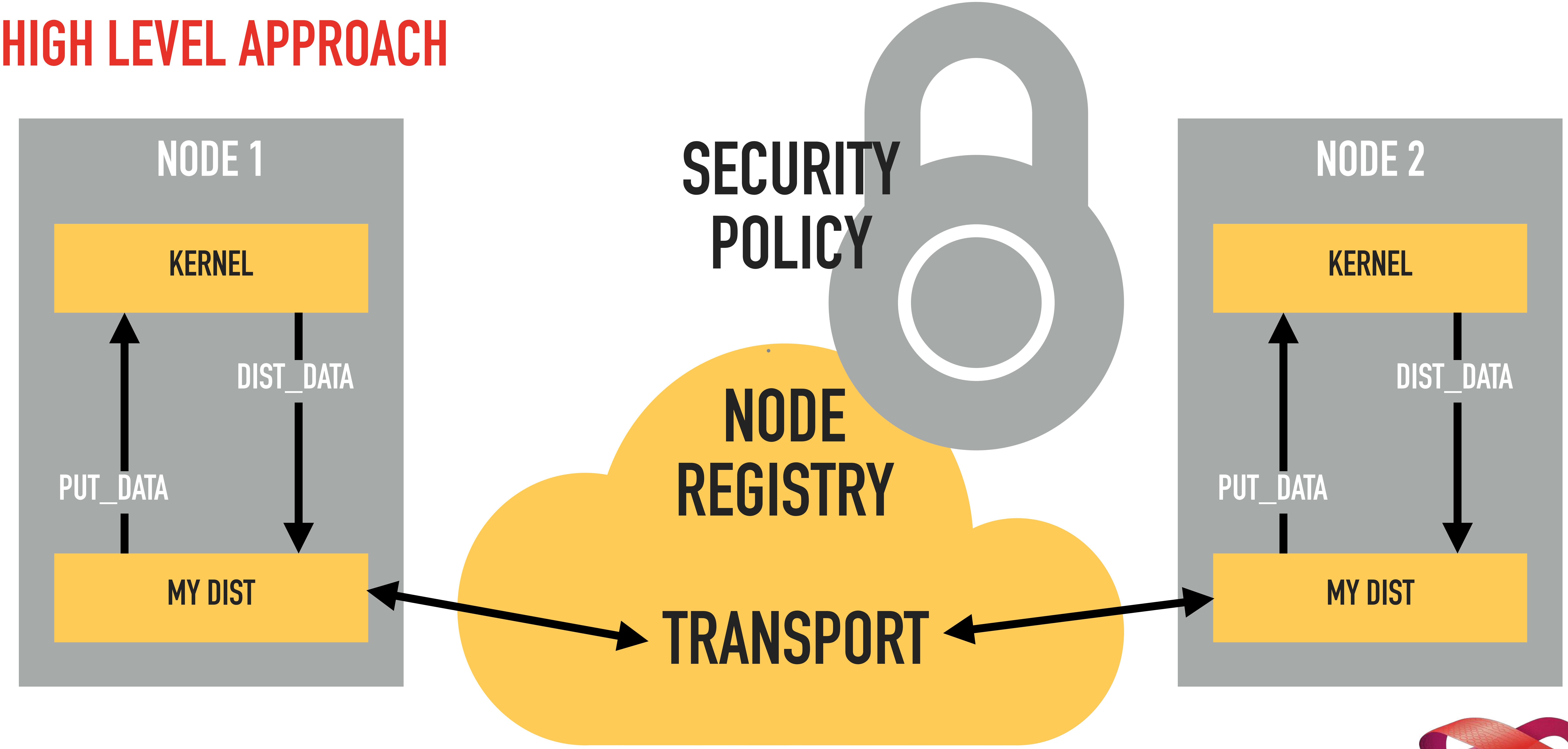
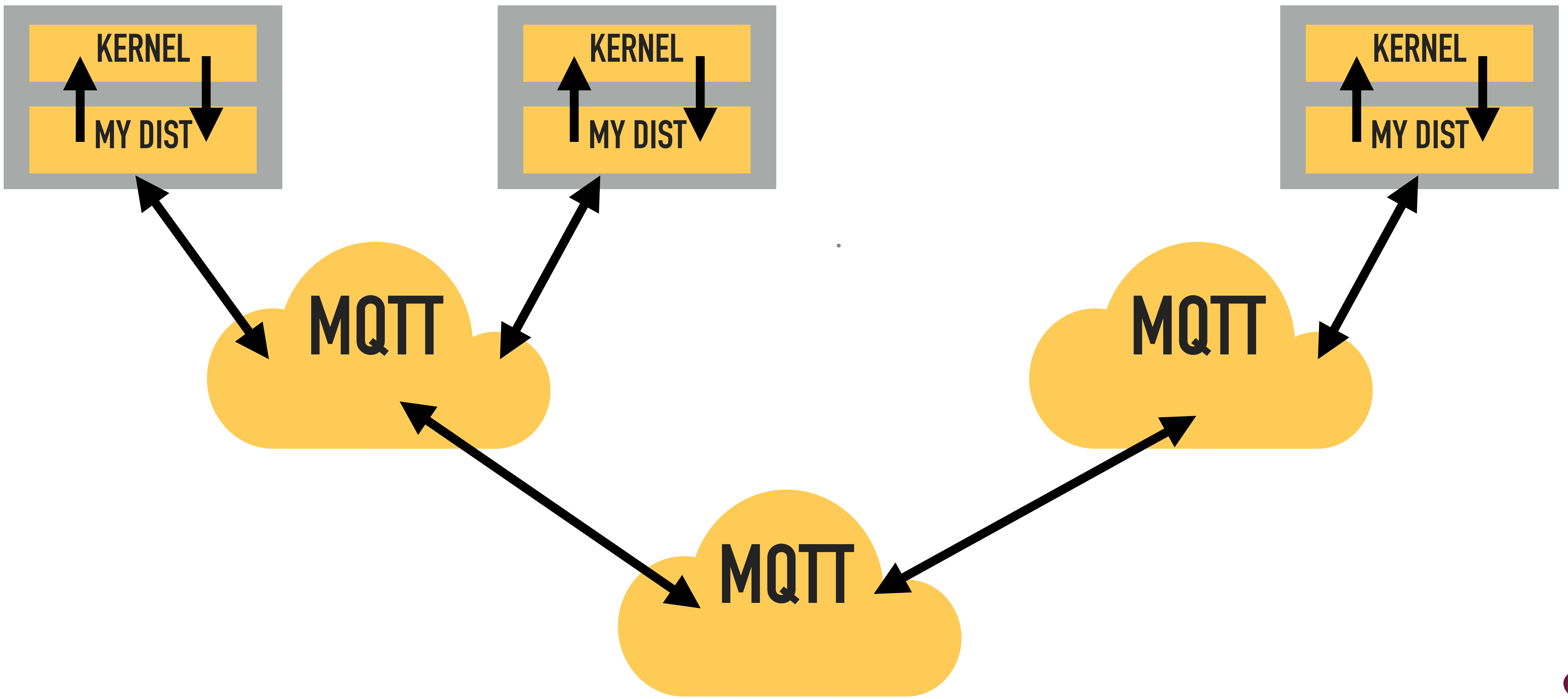
HIGH LEVEL APPROACH



HIGH LEVEL APPROACH



DISTRIBUTION OVER MQTT PUB SUB



HIGH-LEVEL DISTRIBUTION

HETEROGENOUS NETWORKS

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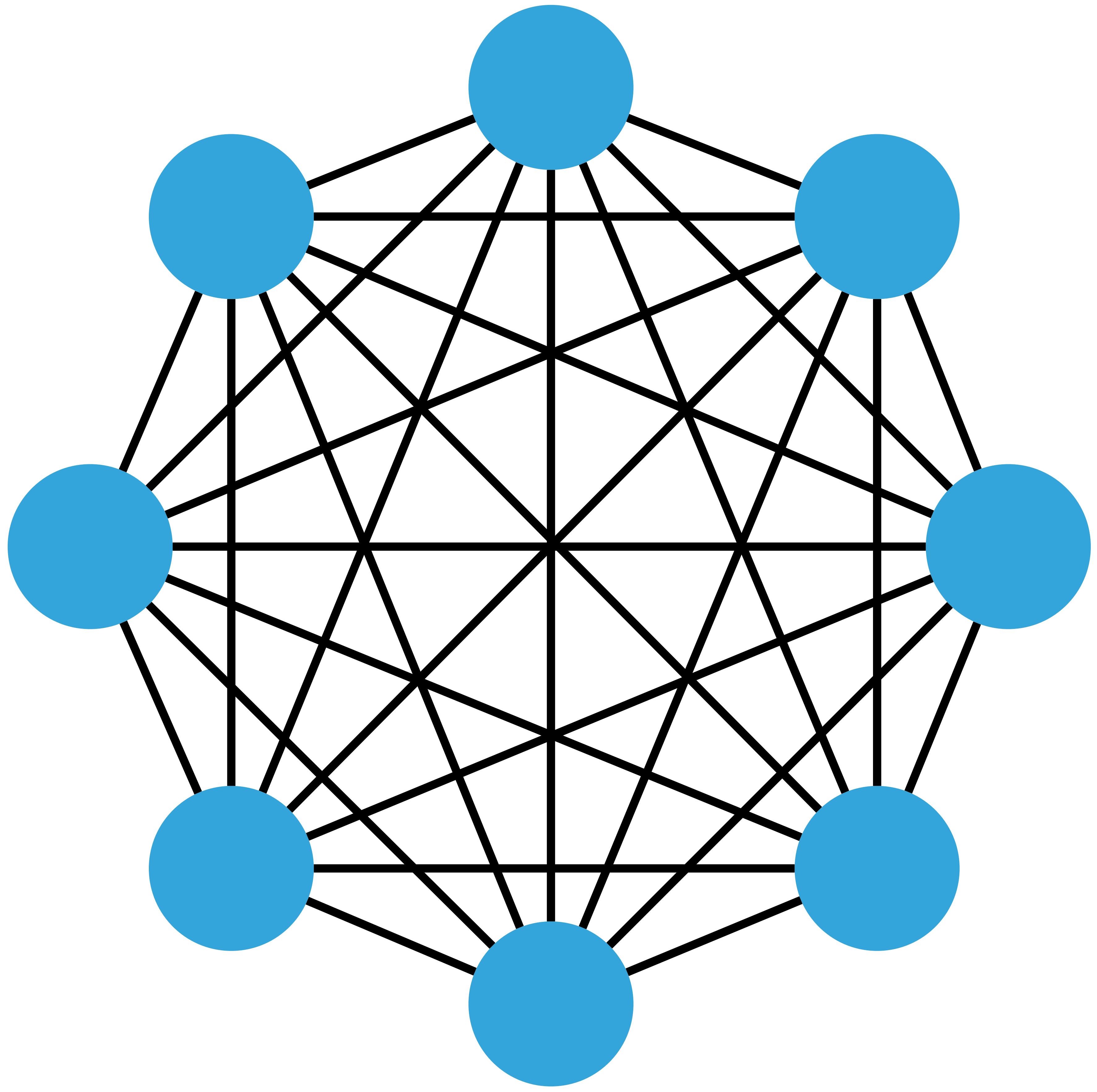
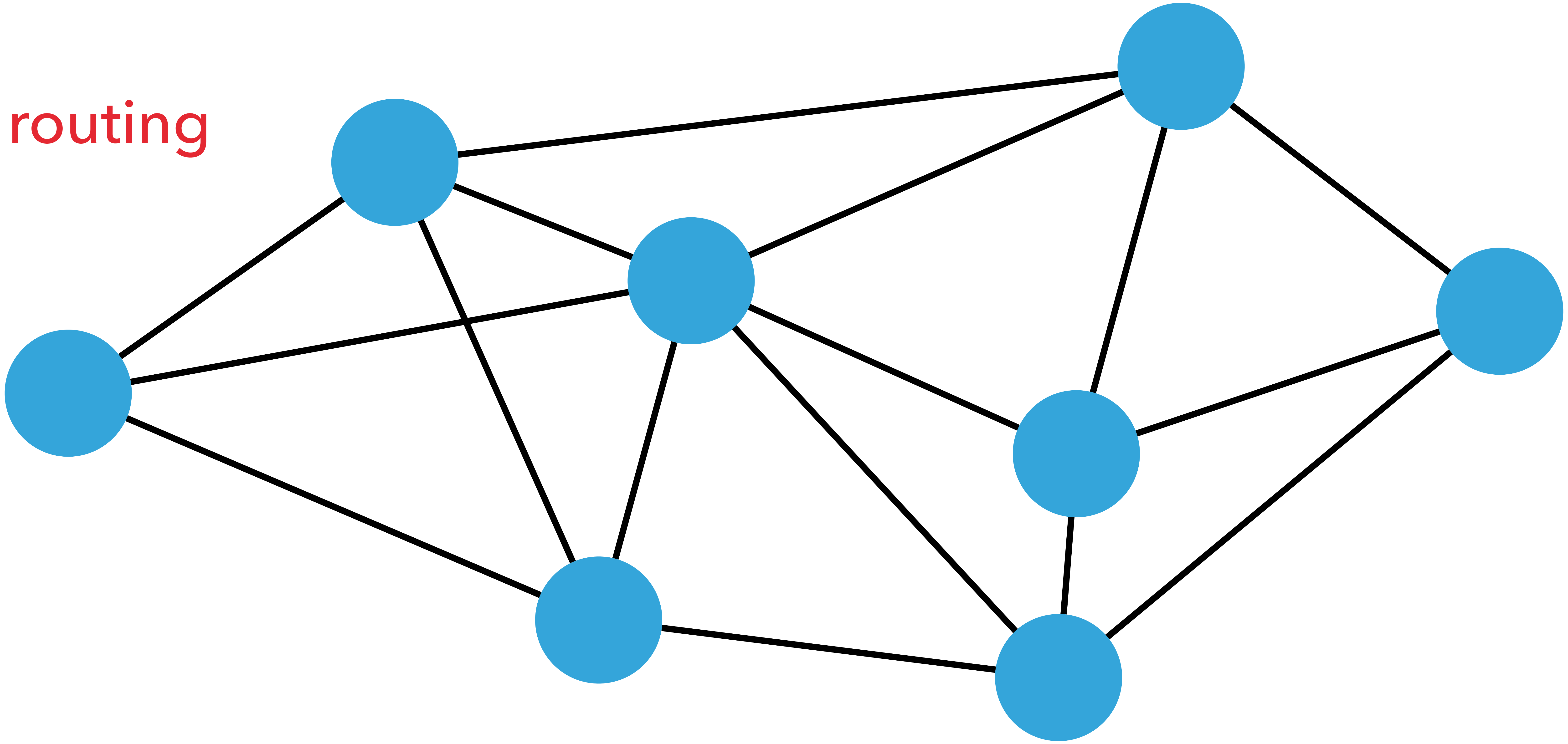
FULLY CONNECTED MESH

- Doesn't scale!



NORMAL MESH

- Scales!
- But needs routing



CUSTOM DISTRIBUTION TO THE RESCUE

- Topologies can be made transparent to the application layer
- Transports can also be made transparent
- Requirements
  - A way to represent “virtual” node connections
  - Can be made transparent to the application

TIME SENSITIVE NETWORKING

ETHERNET TSN

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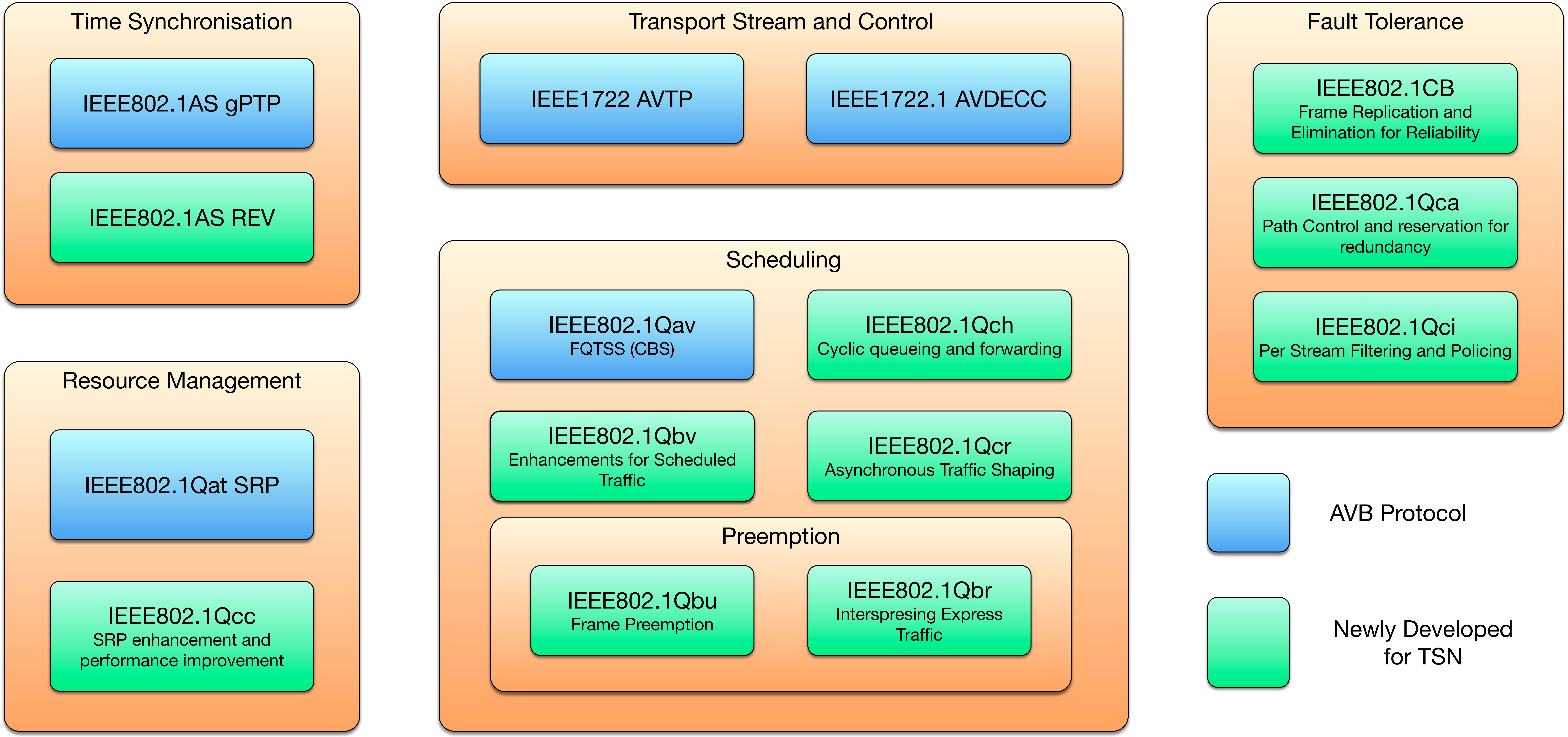
WHAT'S IT ABOUT

- Bounded transmission latency
- Low transmission latency
- Reliable delivery of Ethernet packets

+ HARD REALTIME ERLANG PROCESSES

=

DISTRIBUTED HARD REALTIME APPLICATIONS



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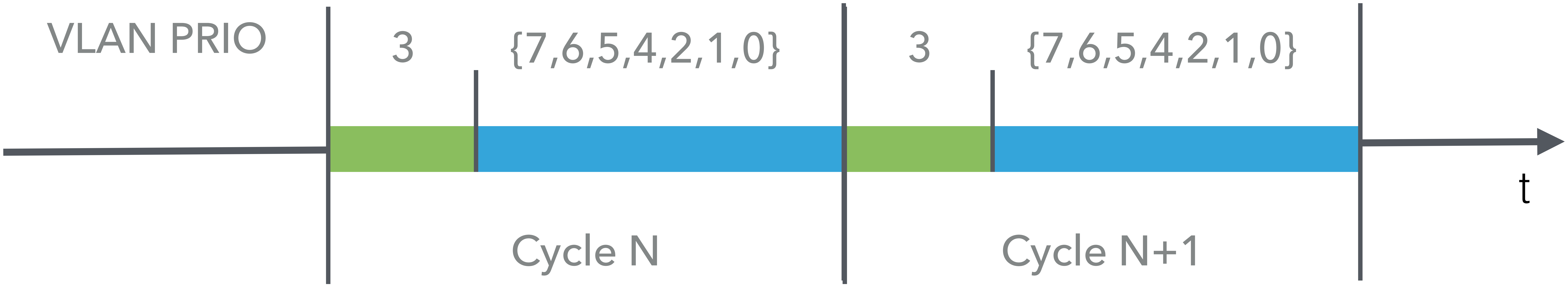
IEEE 802.1Qbv



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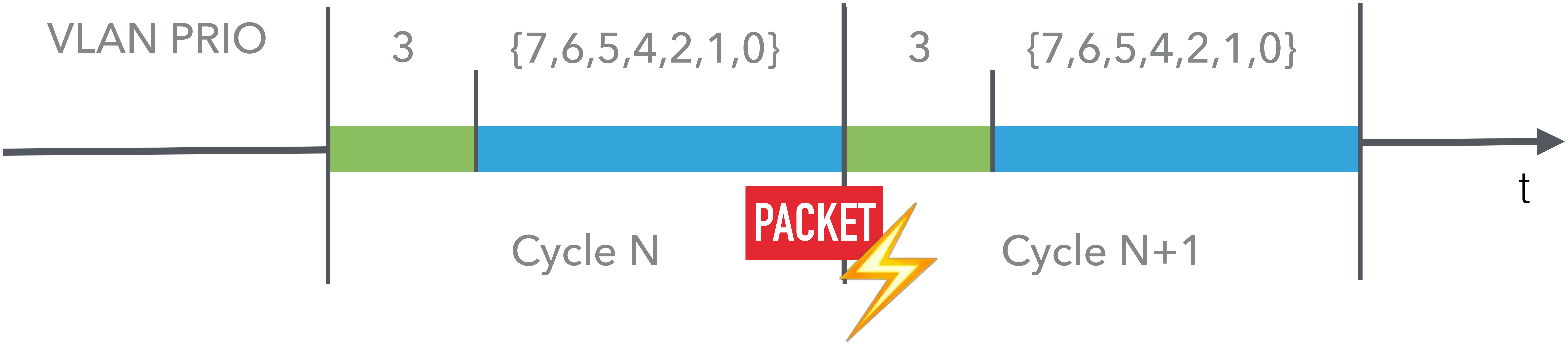
IEEE 802.1Qbv



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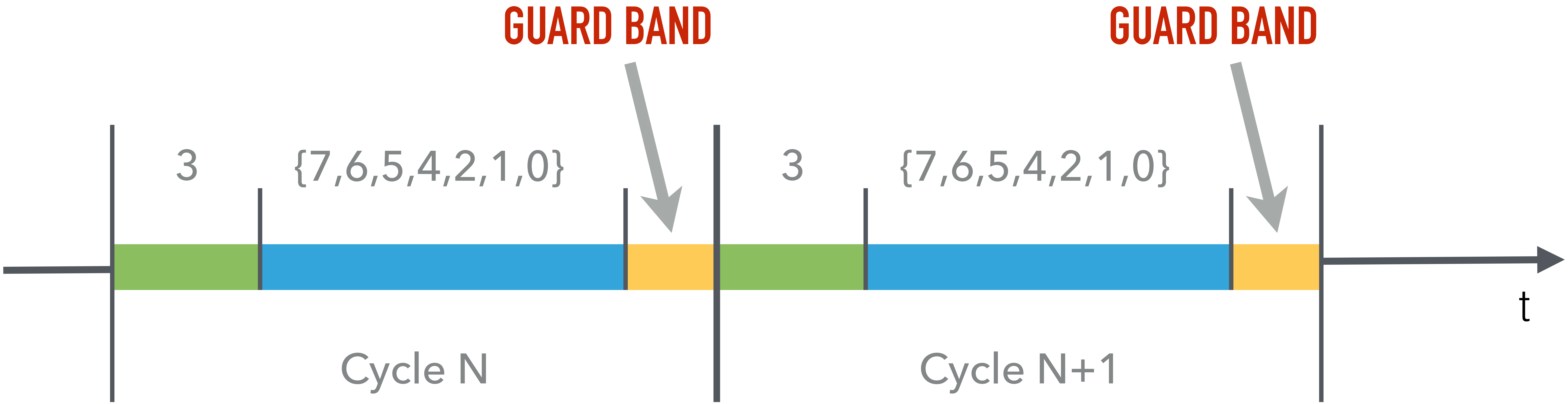

RESULTS & FUTURE WORK

SUMMARY

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RESULTS & CURRENT STATE

- Generic distribution behavior
  - WIP
  - Multiple API alternatives
- TSN
  - Implementing a TSN Switch with Shortest-Path-Bridging
  - Using Erlang for the control plane

FUTURE WORK

- Erlang distribution
  - Connection oriented UDP
    - QUIC
  - MQTT prototype
  - „Virtual node connections“
- Industrial networking
  - Prototype UDP over TSN
  - Implement real-time control prototypes

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