# Philosophy Behind Networking

# “The Networking Philosopher’s Problem”, Jennifer Rexford, 2011

- **Doubts quoted: “**What is networking? “
  - “Is it just **a plethora of protocols acronyms**, mostly consisting of three or four letters.”
  - “Or, are we **a heap of header formats**, for Ethernet frames, IP packets, TCP segments and UDP messages, and application-layer messages?”
  - “So, perhaps we are **a big bunch of boxes** that perform various functions on packets, flows, or TCP connections?”
- **Appeals**
  - Our field is all about change, … But, while we continue to embrace change, I hope that we can **make the questions we ask more precise, and the way we answer them more rigorous,** so we can put networking …on a stronger foundation.
  - I fear **we err too far on the side of valuing new problems over deeper answers to existing questions**. We need to fight this urge, to **encourage more thorough, complete, and deeper research** that truly helps the field “grow up,” without losing its child-like sense of wonder.

# A gap between experience and theory in networking?

- IETF is a unique SDO with many contributions from universities
  - We even have an IRTF!
- But there seems a gap in networking area(as a whole)
  - Innovations and designs rely heavily on experience
  - I don’t find a well-defined body of knowledge, or a systematic set of approaches, which can guide us to
    - Make design choices
    - Understand tradeoffs behind decisions

# Philosophy or Theory

- **Philosophy**
  - Debatable
  - Correct or wrong?
  - Philosophy is math, starting from axioms as assumptions, working out reliable rigorous conclusions or theories
- **Theory**
  - **Explain** existing designs
  - **Predict** new ones
  - Which will guide the engineers when they have to design a solution for a new scenario.
  - For example, an Internet engineer designs a data center network, a network for an AI cluster like NVLINK. Or even network on chips to connect CPU cores.

# More specifically, two questions for theory

1. Potentials
    - Given some conditions, what can you expect to achieve assuming an ideal design?
    - E.g., Shannon's theory/limit.
2. Tradeoffs
    - If you want to achieve better performance in this direction, what are the consequences? What shall I expect to sacrifice?
    - E.g., CAP theory in the database?

# Examples for Networking: two key design issues

(1) For a routing protocol

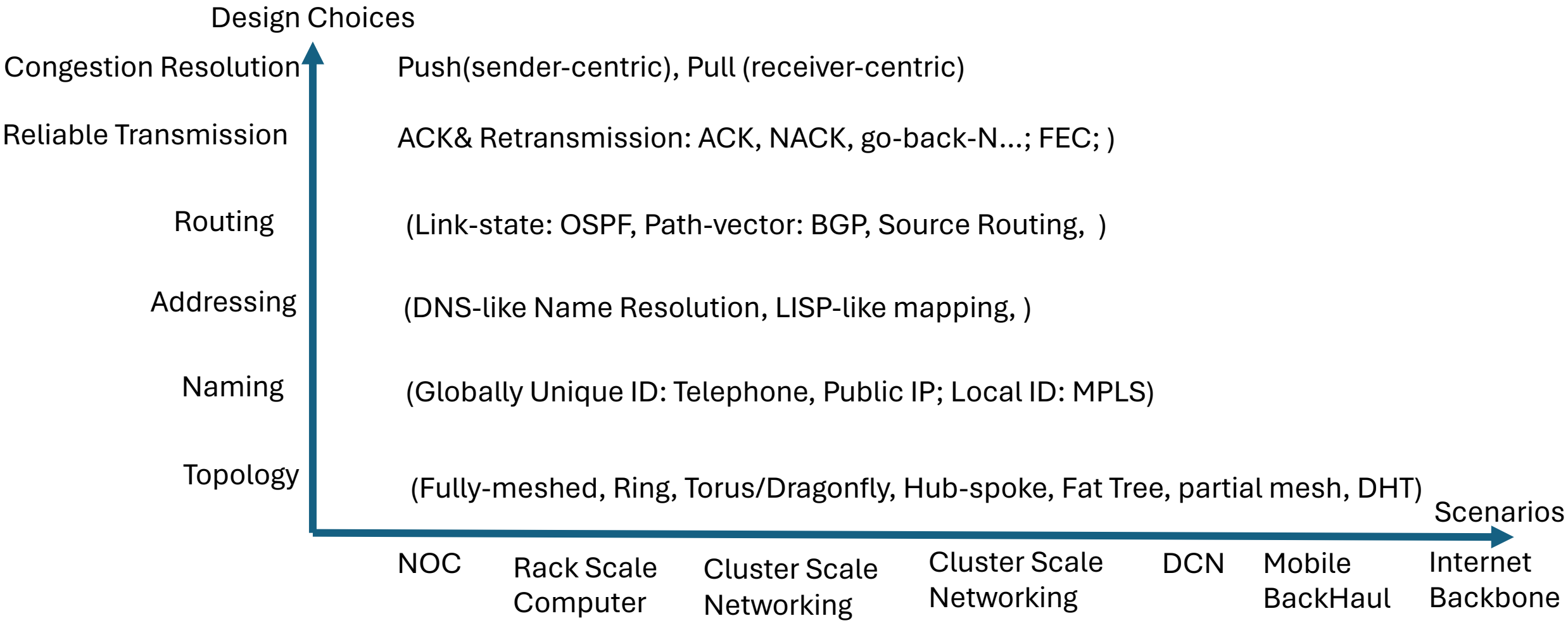
- There is a tradeoff between convergence time, scale (number of nodes, geographic distance), and the bandwidth for the protocol.
- Such a tradeoff will help to find new ideas: if we allow the bandwidth for the protocol to be up to 10Gbps, can we design a new routing protocol that is convergent 10 times faster than today?

(2) For the transport protocol

- Reliability, rate control (congestion resolution)
- There is a tradeoff between packet loss, line utilization, delay, and buffer size.
- NUM theory solves this for long living flows. NUM provides a good theory for long-live flows. What about if the objective is **flow complete time**, **message complete time**, **collective flow complete time**, or **probabilistic computation**?
- What if we add “fairness” to these “ complete-time ” objectives? There are various fairness types in game theory.

# The landscape of networking

The network is critical for distributed systems, but when we move from one domain to another, we only have experience, not theory, to tackle the new challenges.



# Questions

- What kind of tradeoffs have you met during your research or work?
- Or,
- What kind of limitations (upbound) have you envisioned in network designs?

- Can we develop these tradeoffs/limitations into theory?