Symbiotic Apps-Wireless Architecture Via Named Data

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http://ice-ar.named-data.net/

B5G Challenges for Wireless Edge

To enable B5G networking & applications:

- Low latency, high throughput, support for heterogeneous wireless technologies
- Seamless integration of computing, in-network storage, & communication @ edge
- *Resilient networking*
  - *works in either normal or disruptive environments*

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Limitation of State-of-the-Art

- The innovations of apps and wireless are **moving apart** from each other
  - Separated by TCP/IP protocol stack

- **Application**: Unaware of underlying wireless dynamics and multiple interfaces

- **Wireless**: Unaware of application-level demands and communication patterns

Prior Work: Mobile-Empowered AR/VR in 4G Wireless

Tango

Daydream + Cardboard

Prior Work: Mobile-Empowered AR/VR in 4G Wireless

What we have learnt

1. TCP/IP stack prohibits information sharing between app and wireless
   - Their low-latency potentials are not fulfilled

2. Wireless bandwidth is a bottleneck, but not the only one
   - Yet app may be unaware when bandwidth suffices

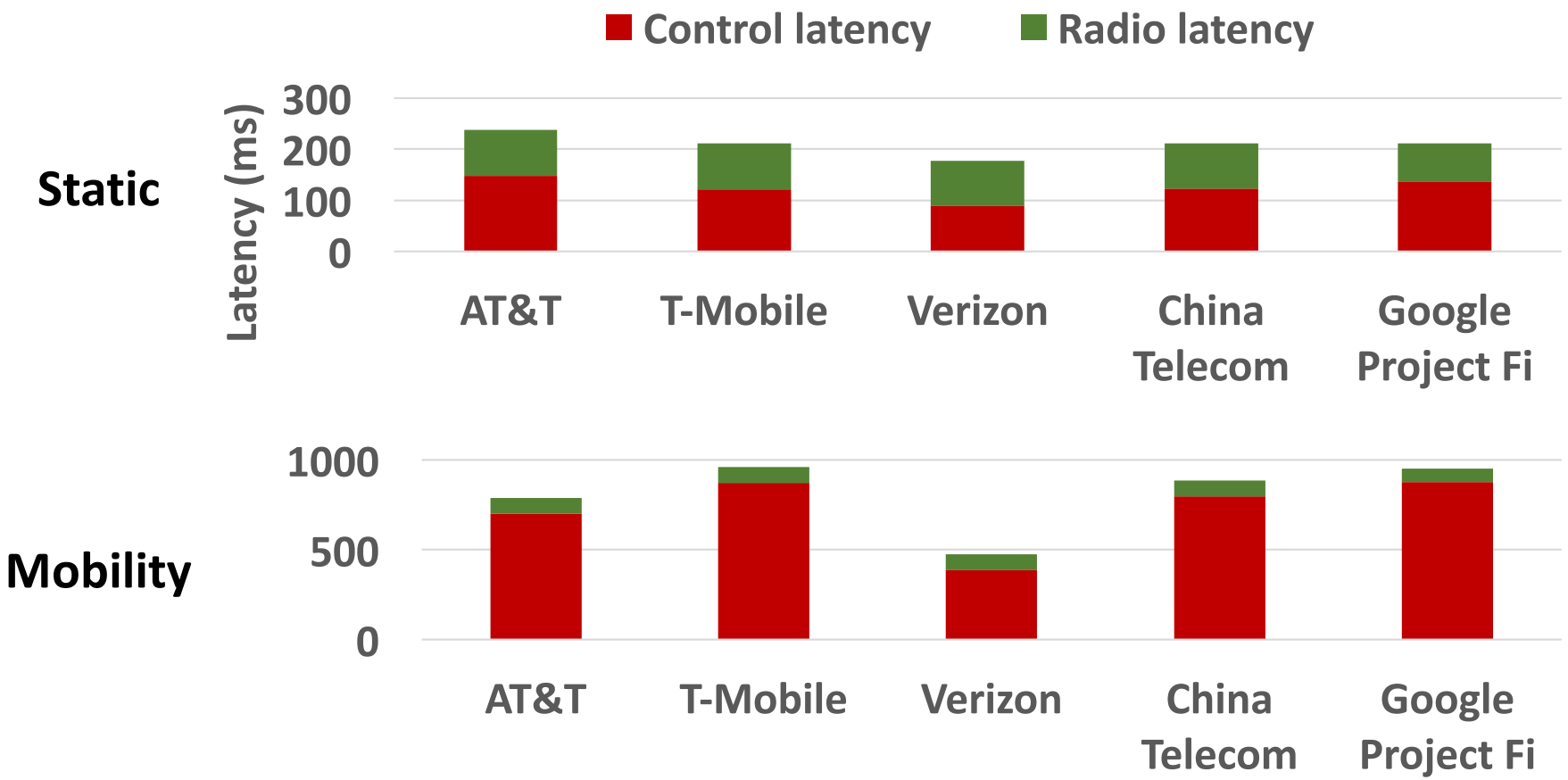
3. Protocol signaling overhead is an equally important latency bottleneck[1]
   - Maintain wireless connectivity
   - Support consumer mobility

[1]"A Control-Plane Perspective on Reducing Data Access Latency in LTE Networks", ACM MobiCom'17

Prior Work: Mobile-Empowered AR/VR in 4G Wireless

88.28-962.2ms per connectivity setup/migration

- Comparable to wireless link latency

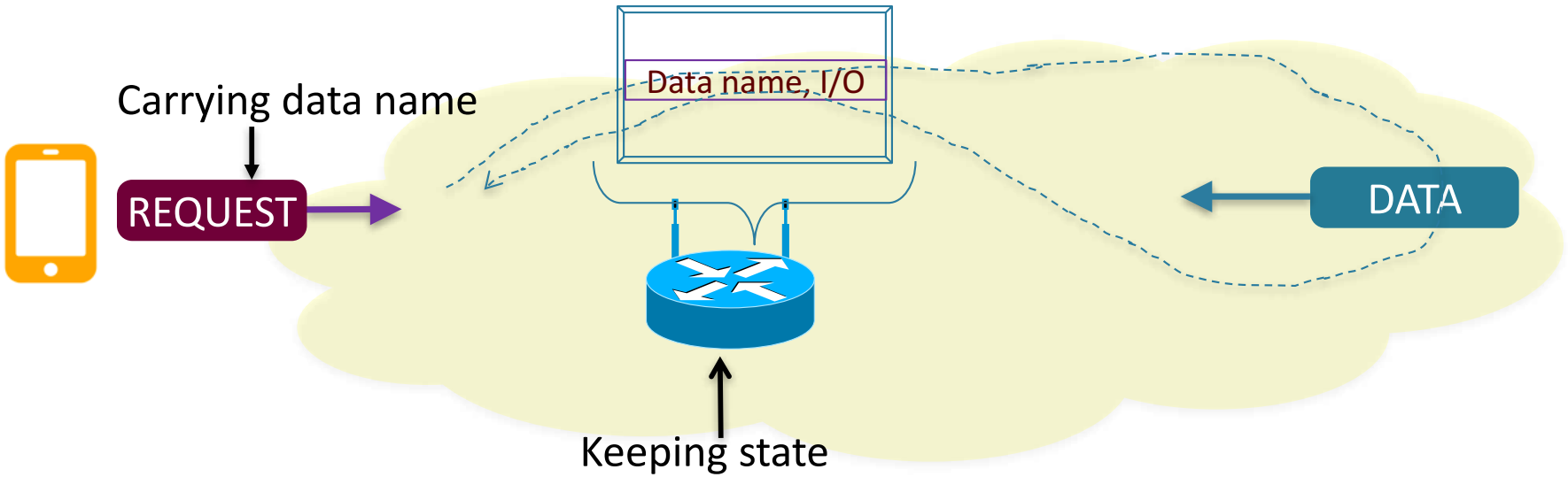


"A Control-Plane Perspective on Reducing Data Access Latency in LTE Networks", ACM MobiCom'17

How ICE-AR Bridges the Gap between App & Wireless in B5G

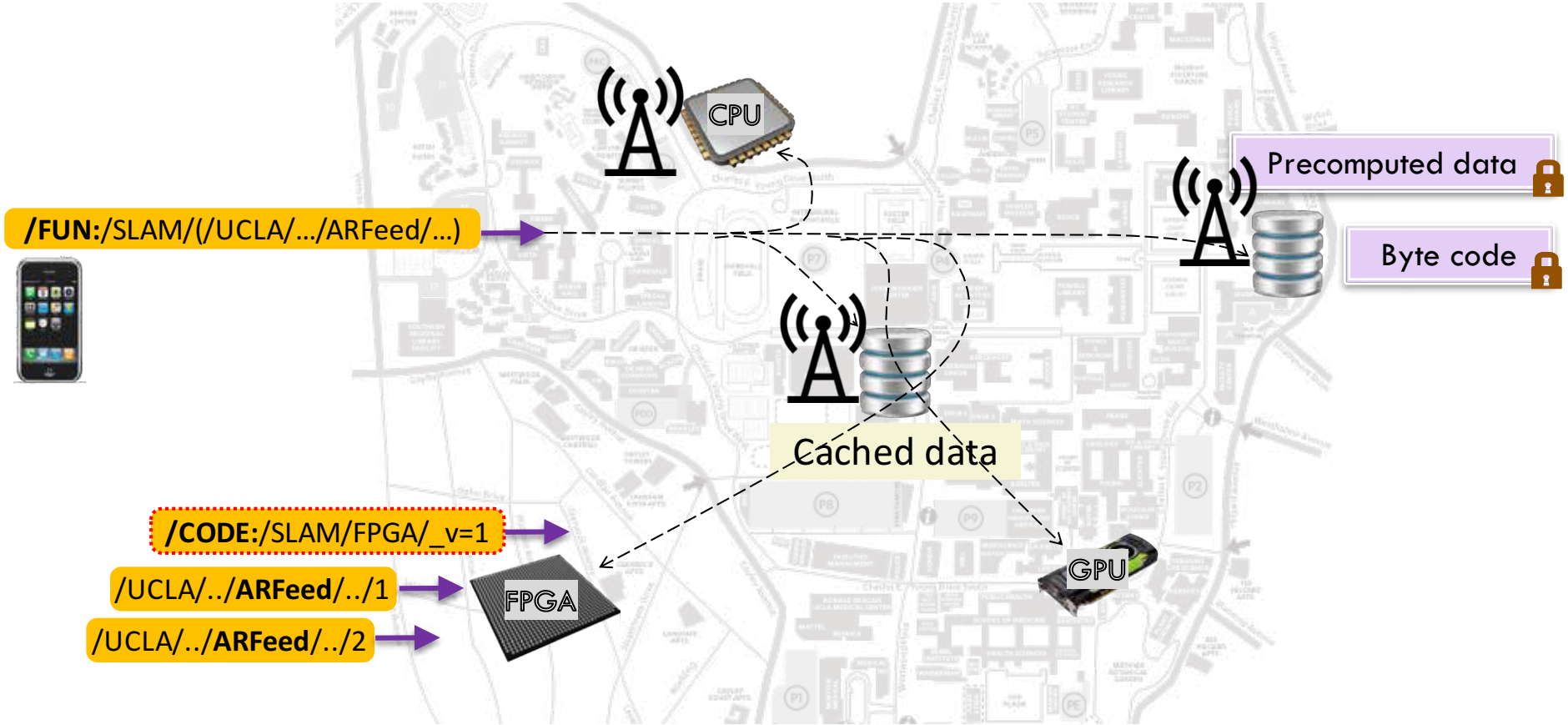
Desirable Features by NDN

1. Fetching data by application names
2. Stateful forwarding plane with closed feedback loop
3. Built-in support for
   - Rich patterns: one-one, one-many, many-one
   - Integrating heterogonous wireless interfaces
   - Seamless consumer mobility



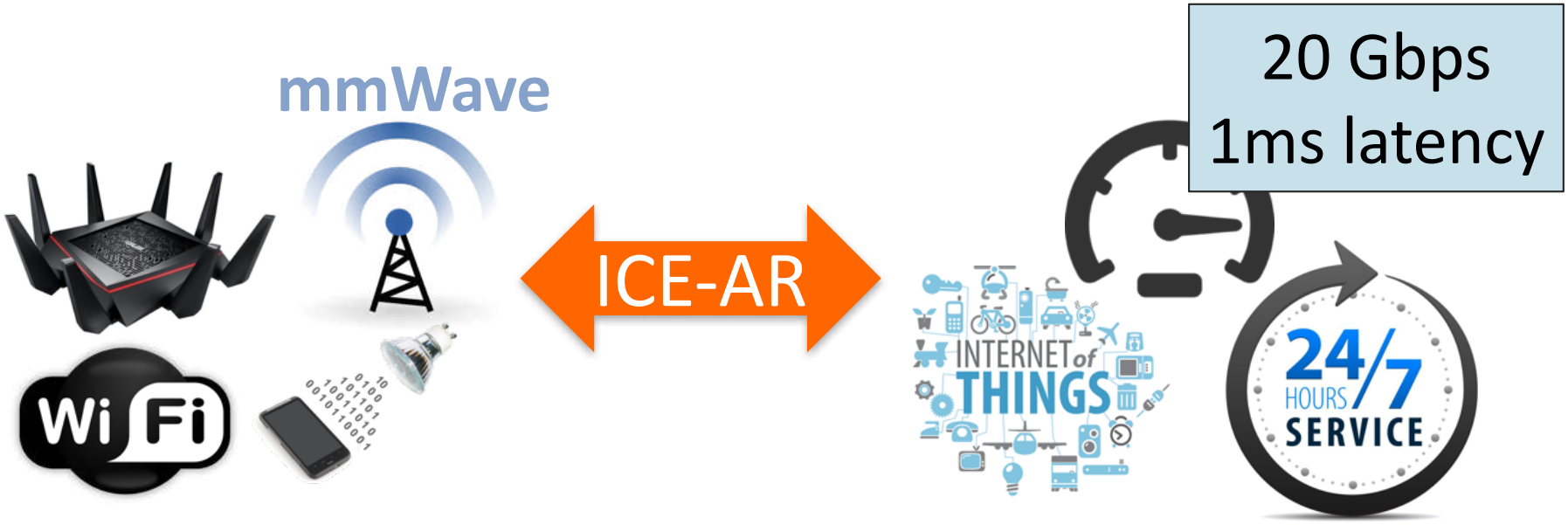
Integrating Computation, Storage & Wireless Networking

- Networking: Fetch data from wherever possible
- Processing: Dynamic reconfigurable acceleration
- Storage: Opportunistically caching at any node



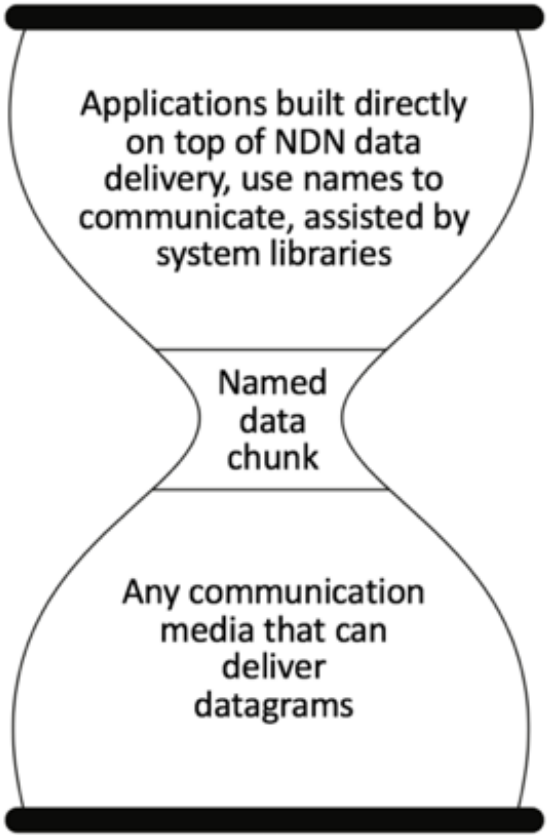
ICE-AR Communication Plane

- A right architecture enables full exploitation of new technologies
- Network architecture is to bridge the gap between what app wants and what wireless technology can provide



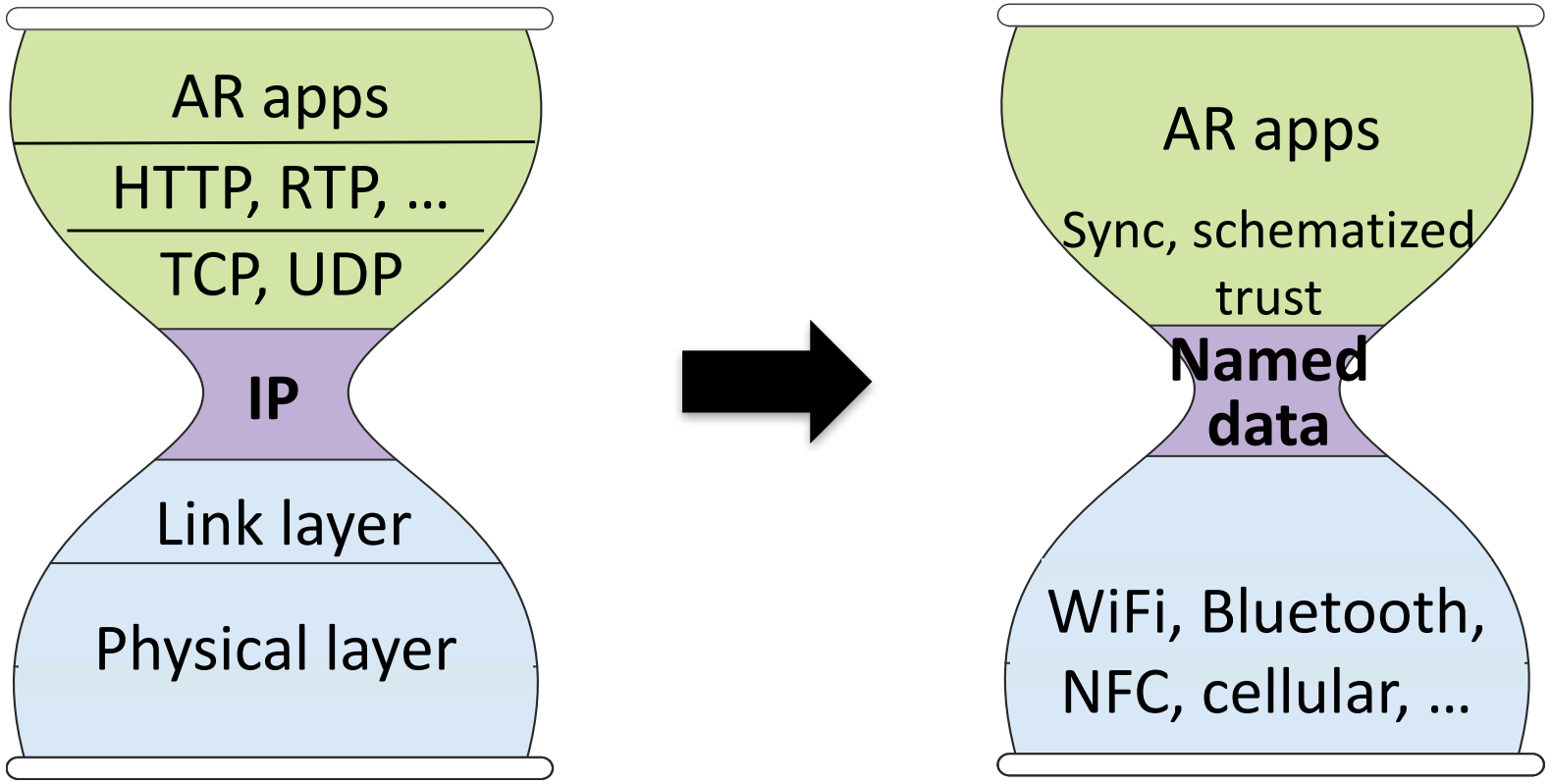
ICE-AR Information Plane

- NDN as the architecture foundation
- New "Thin waist"
  - Bridging AR application and communication plane
- Co-design with the wireless communication plane



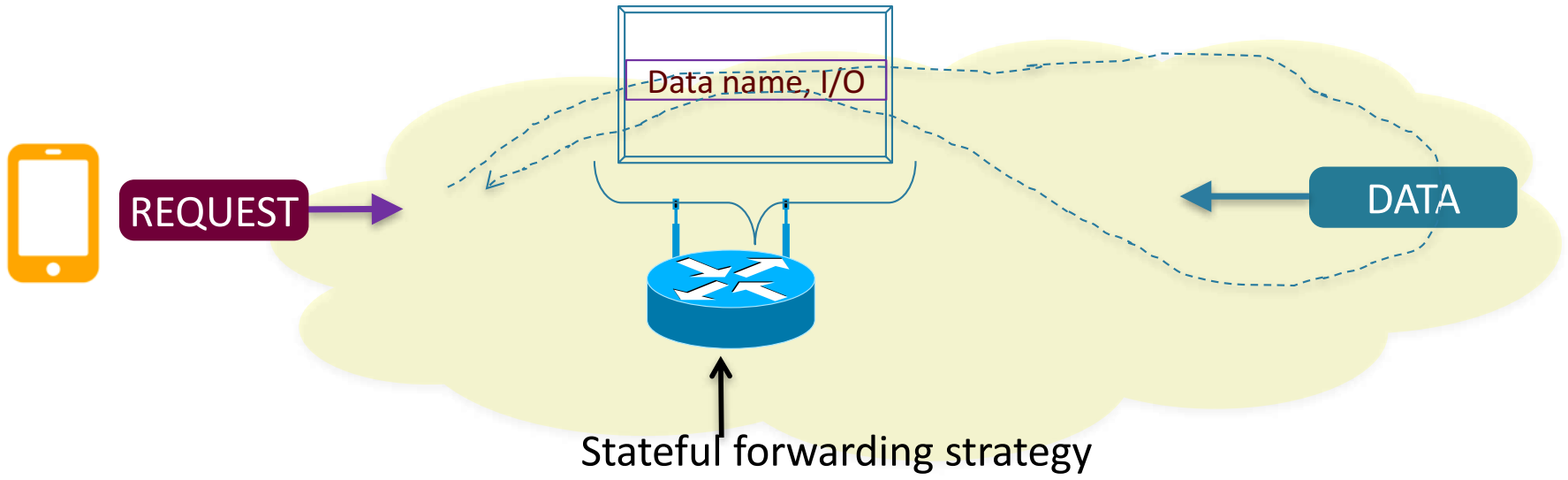
Co-Design App & Wireless @ Edge

- Close the gap: Minimal Layering via Naming
  - NDN *directly* over wireless
  - Reduce layered processing latency
  - Facilitate info sharing between wireless and app



Co-Design App & Wireless @ Edge

- Wireless-Aware App: Adaptive contents
  - En-route data processing through naming
    - Balance the workload between computing and networking
  - Adaptive forwarding strategy
    - With dynamic wireless info: bandwidth, delay, loss ratio…
    - From hetergeneous interfaces: WiFi, bluetooth, LTE, …



Co-Design App & Wireless @ Edge

- App-aware Wireless: Cross-layer Optimization
  - On-demand virtual wireless link access: Aggregation or inverse multiplexing
  - Wireless MAC tailored to diverse communication patterns (one-one, one-many, many-one, …)
  - Avoid signaling overhead w/ built-in mobility support

Achieving Resilient Connectivity

- In-network storage and caching shields disruption to connectivity
  - Popular "content" makes itself most available
- Realizing multipath data delivery in B5G
  - Multiple wireless technologies cover each other for resiliency
- Support for mobility
  - Built-in support for mobile consumers
  - Enhancing NDN with intrinsic support for mobile producers

Summary: Three Takeaways

- Named data glues apps and wireless
- Co-design of NDN & Wireless to make ICN work in reality at wireless edge
- AR as the driving application scenario to push B5G networking research forward

The End