

# Distributed Functionality of OpenHarmony

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# OpenHarmony is a Distributed OS

- **Observation and vision**

- People tend to use more and **more smart devices**



smartphone



smartwatch



pad



mirror



car

...

- **Distributed functionality in OpenHarmony**

- Connect **multiple smart devices** into **a single super device**
- Enable apps to utilize remote hardware, remote data, etc.

# Distributed OS: Use Cases

- Use Pad to draw figs
- Play games with bigger screen



# Outline of Distributed OS

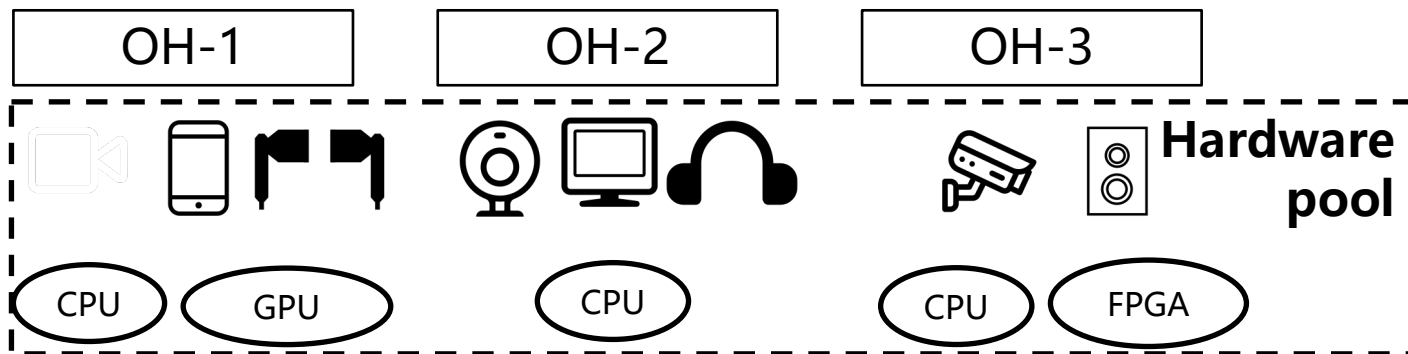
- **Distributed hardware/devices**
- **Distributed software bus (D-softbus)**
- **Distributed data**
- **Distributed security**



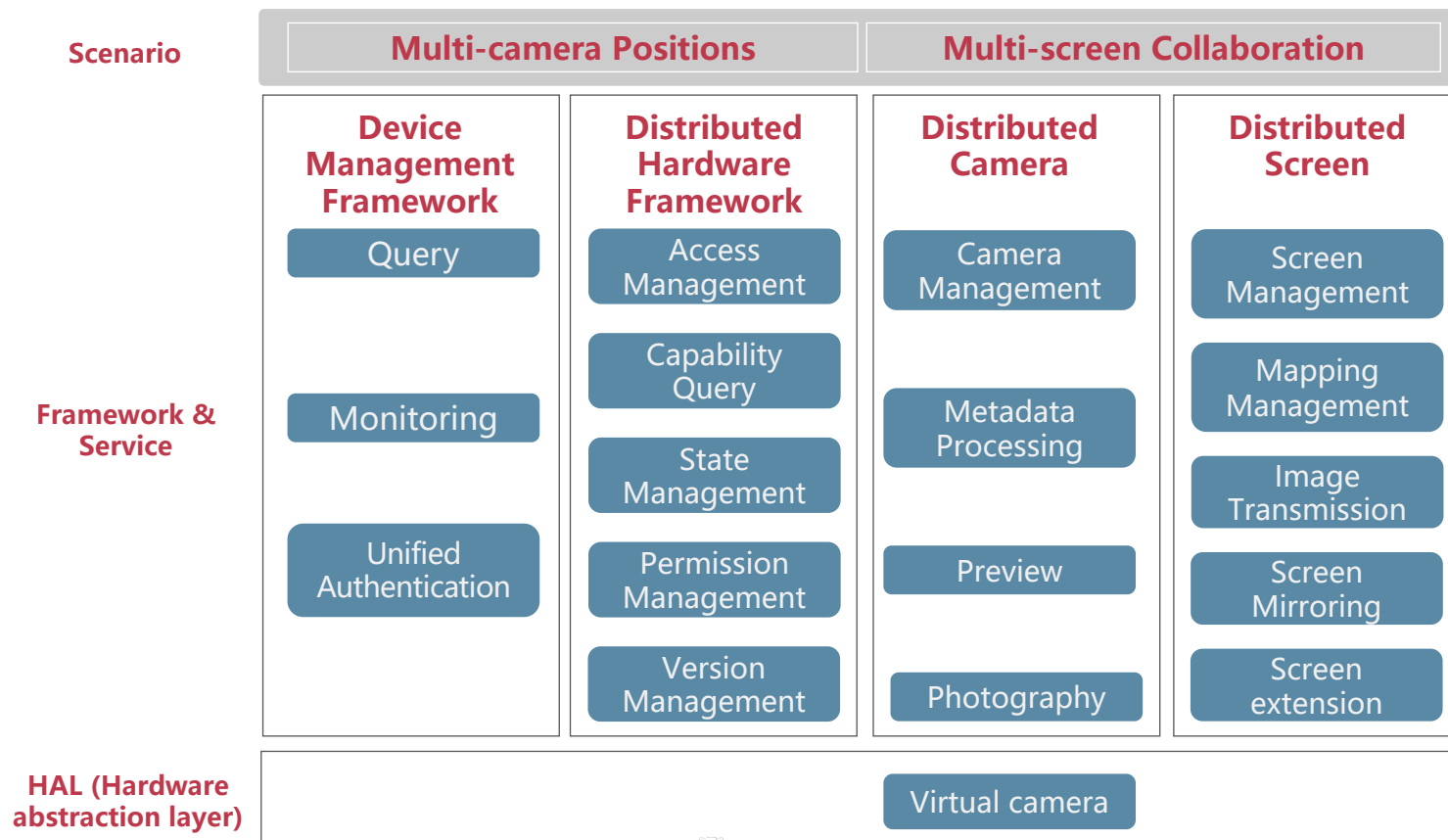
# DISTRIBUTED HARDWARE

# Distributed Hardware

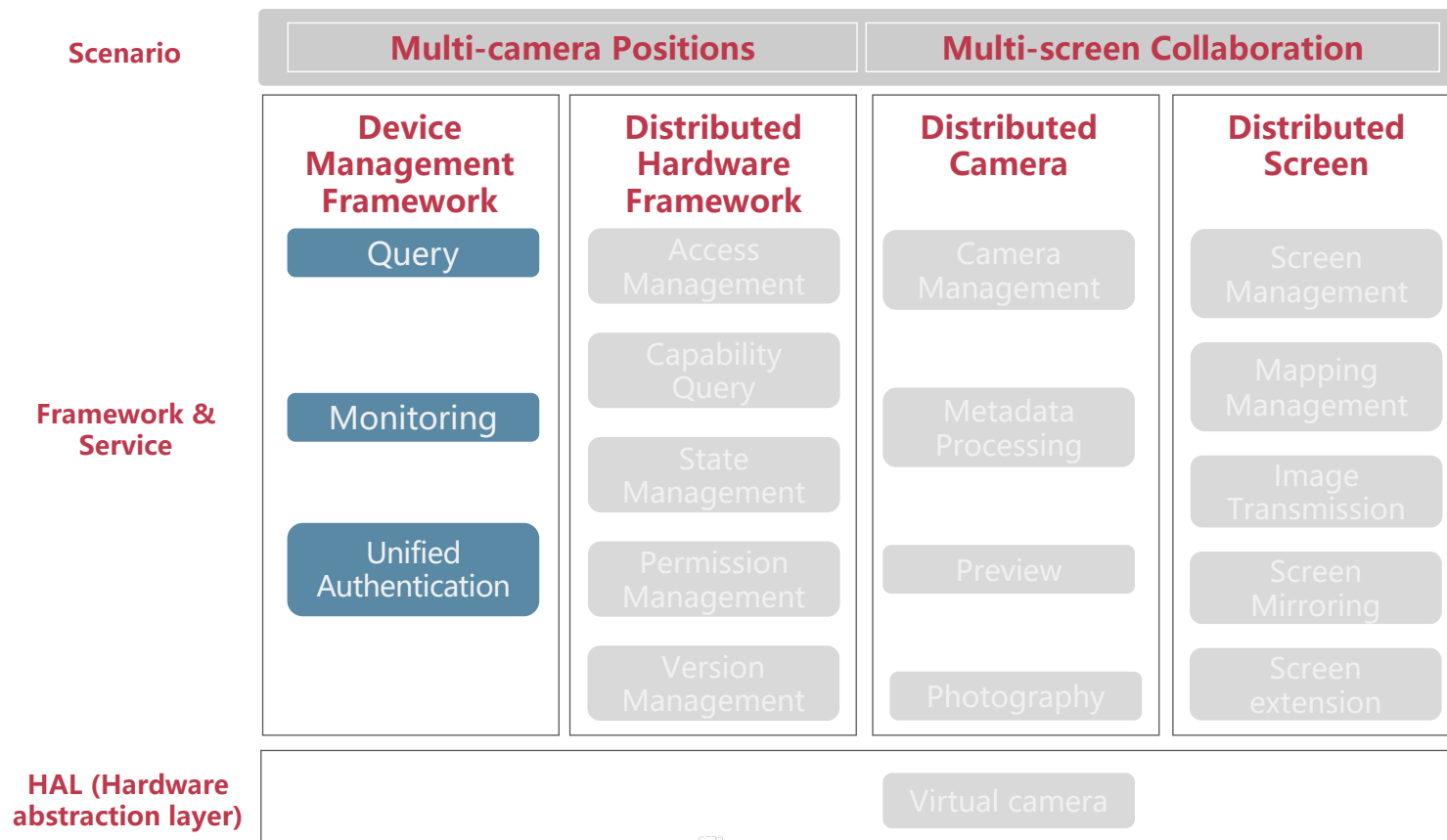
- **Multiple devices can share their hardware**
  - E.g., one device can directly access remote GPU for computation
- **OpenHarmony provides system supports for distributed hardware**



# Distributed Hardware in OpenHarmony

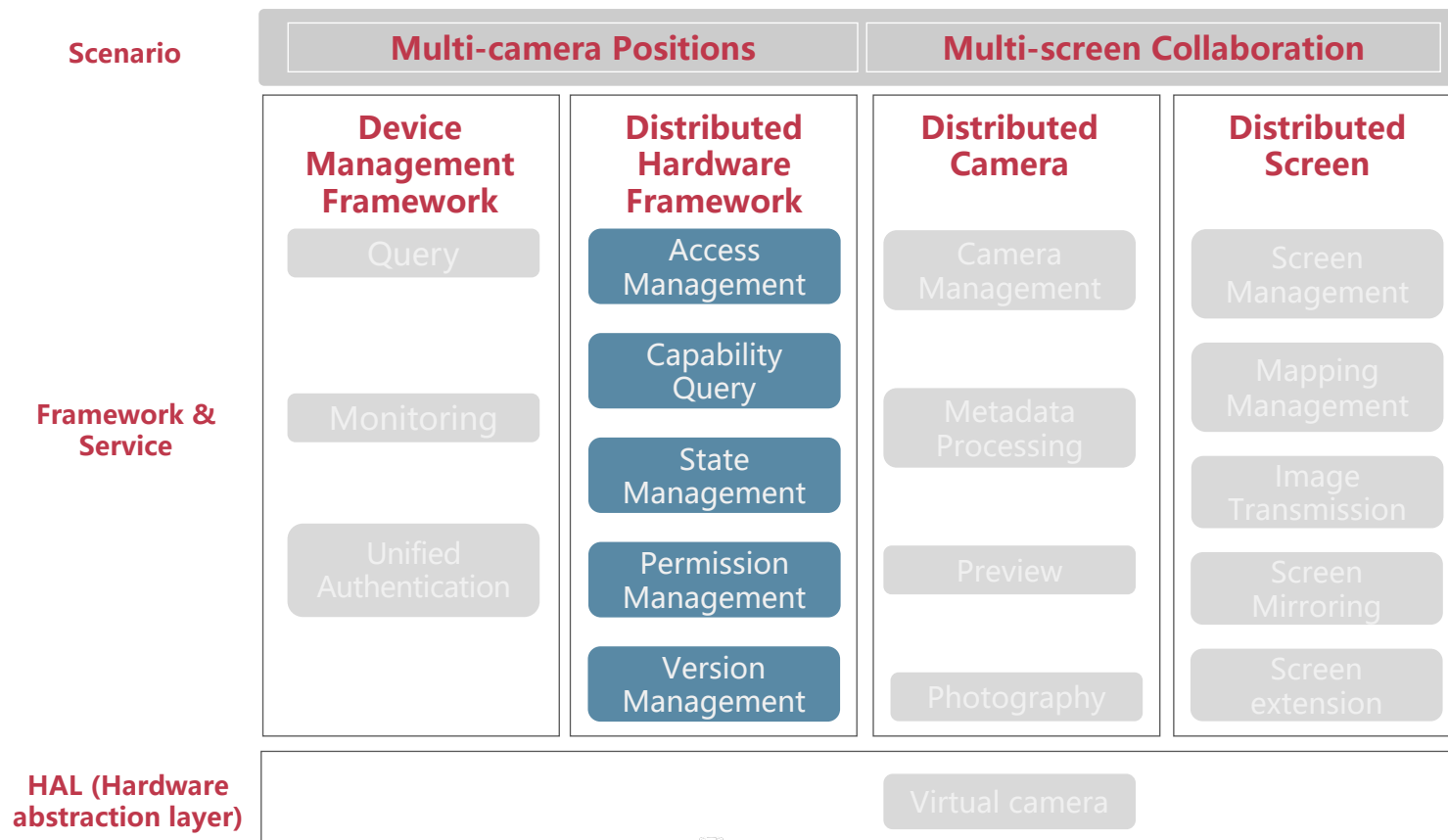


# Distributed Hardware in OpenHarmony

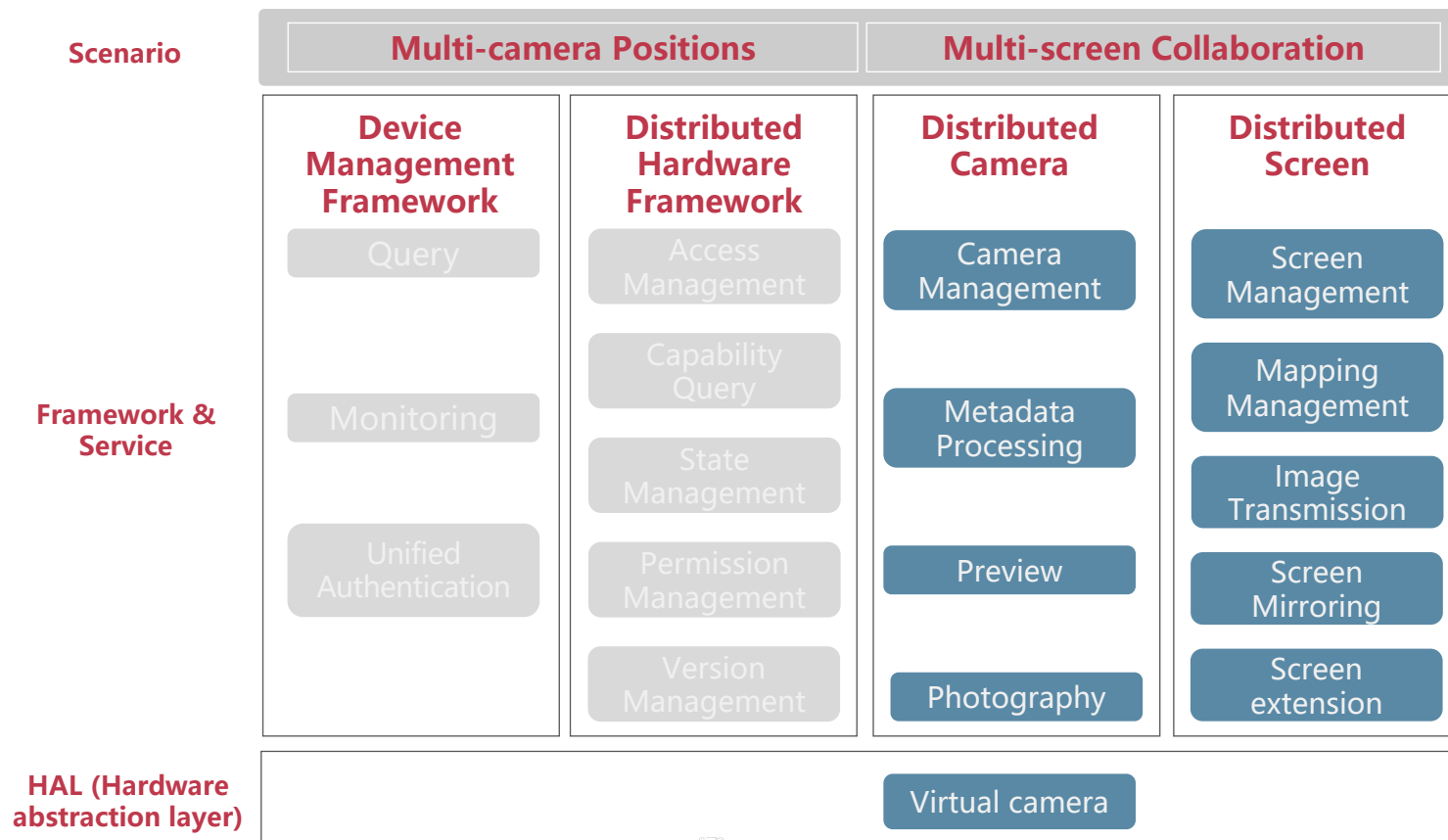




# Distributed Hardware in OpenHarmony



# Distributed Hardware in OpenHarmony

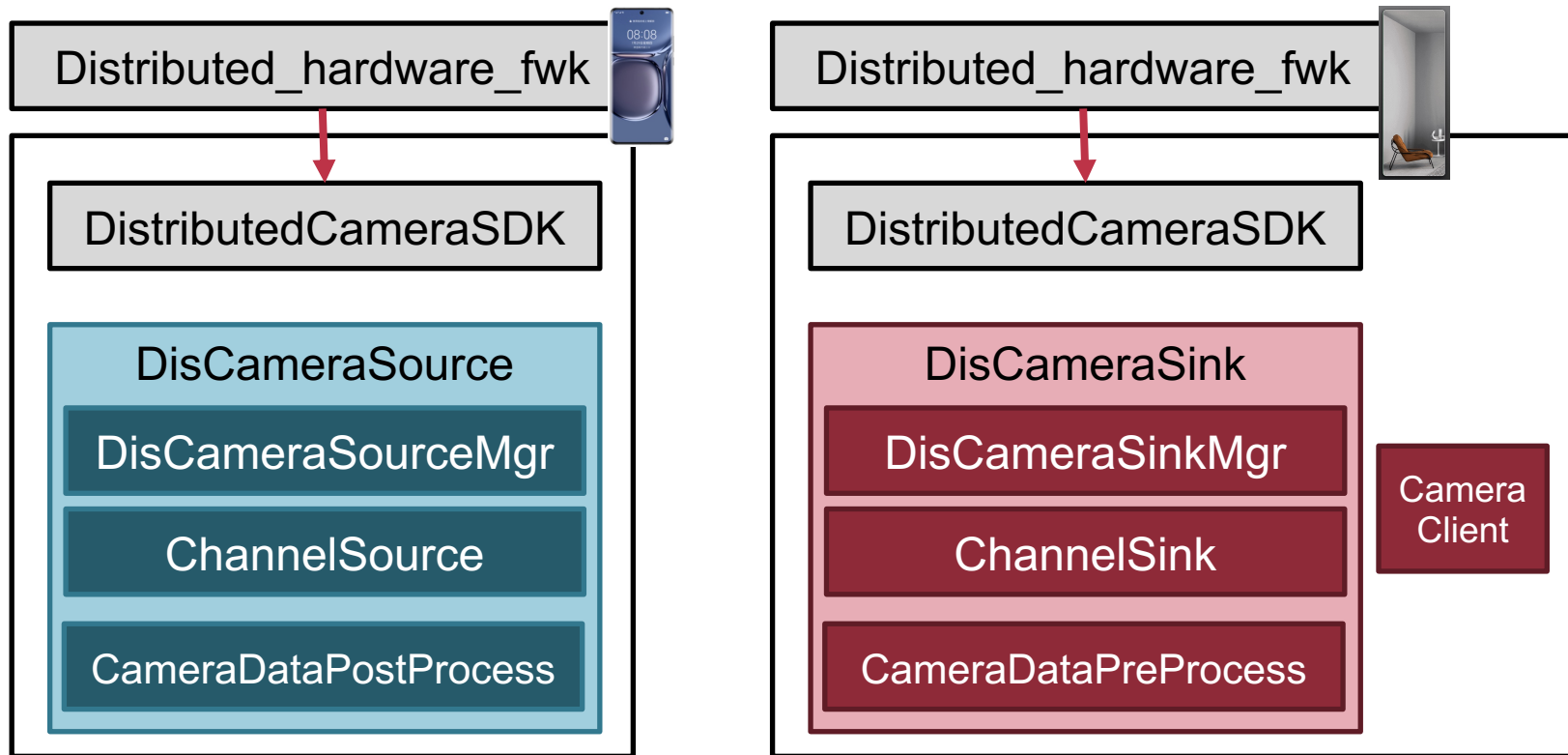


# Distributed Hardware: Distributed Camera

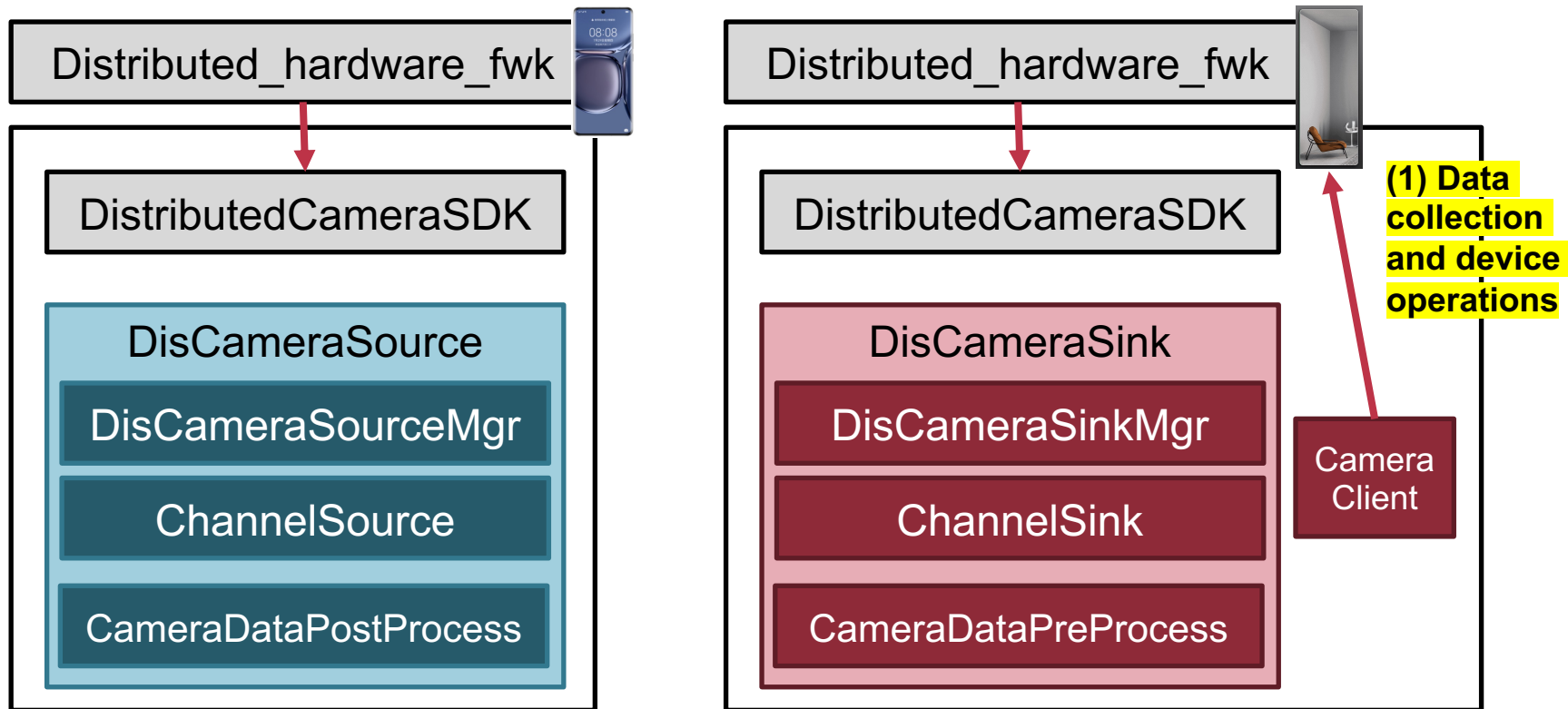


Full-length mirror

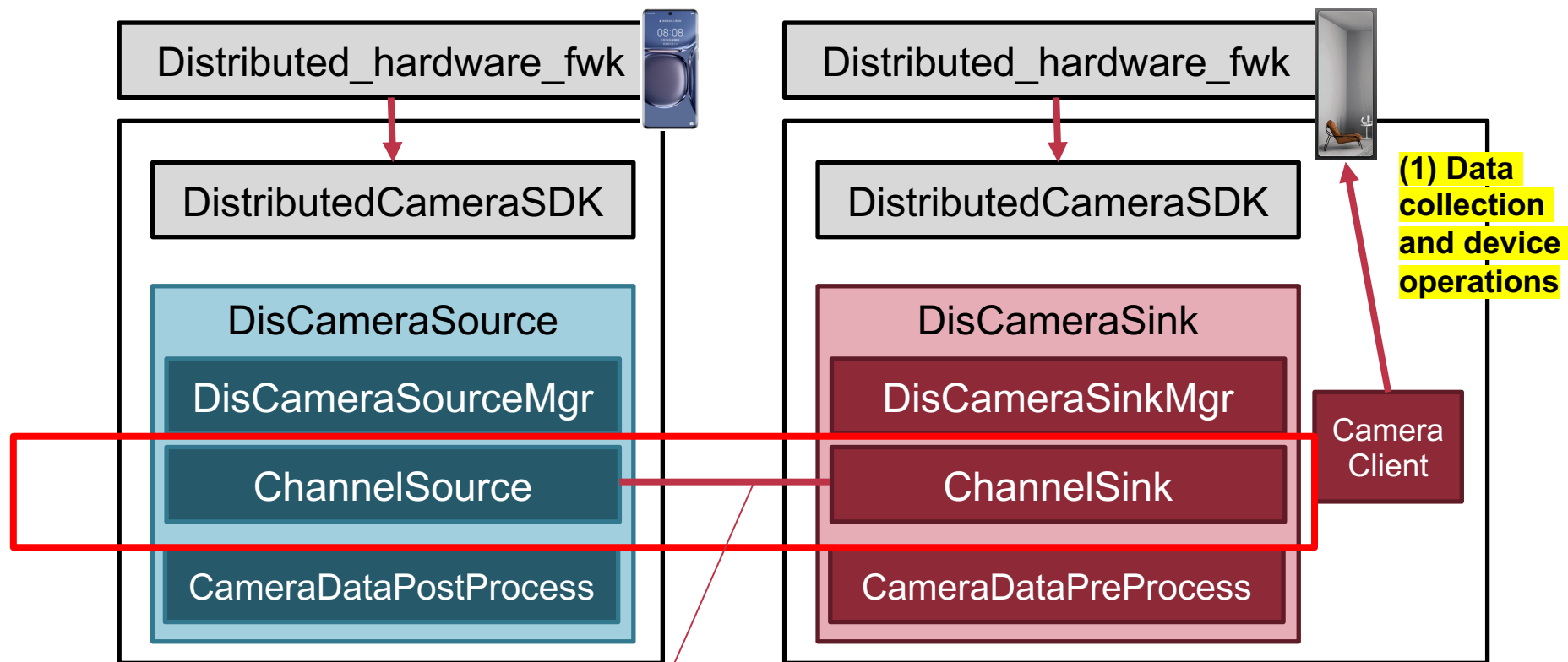
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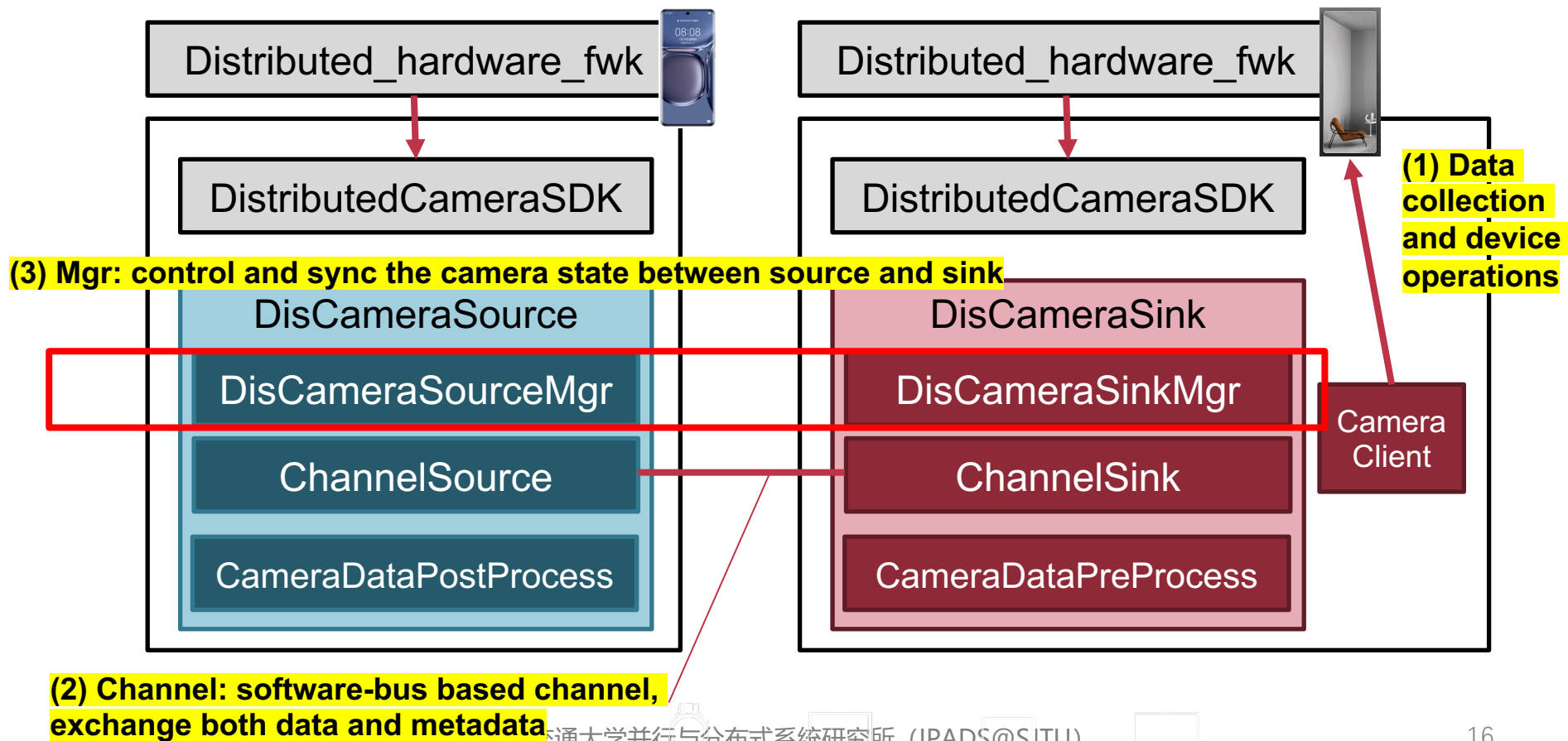


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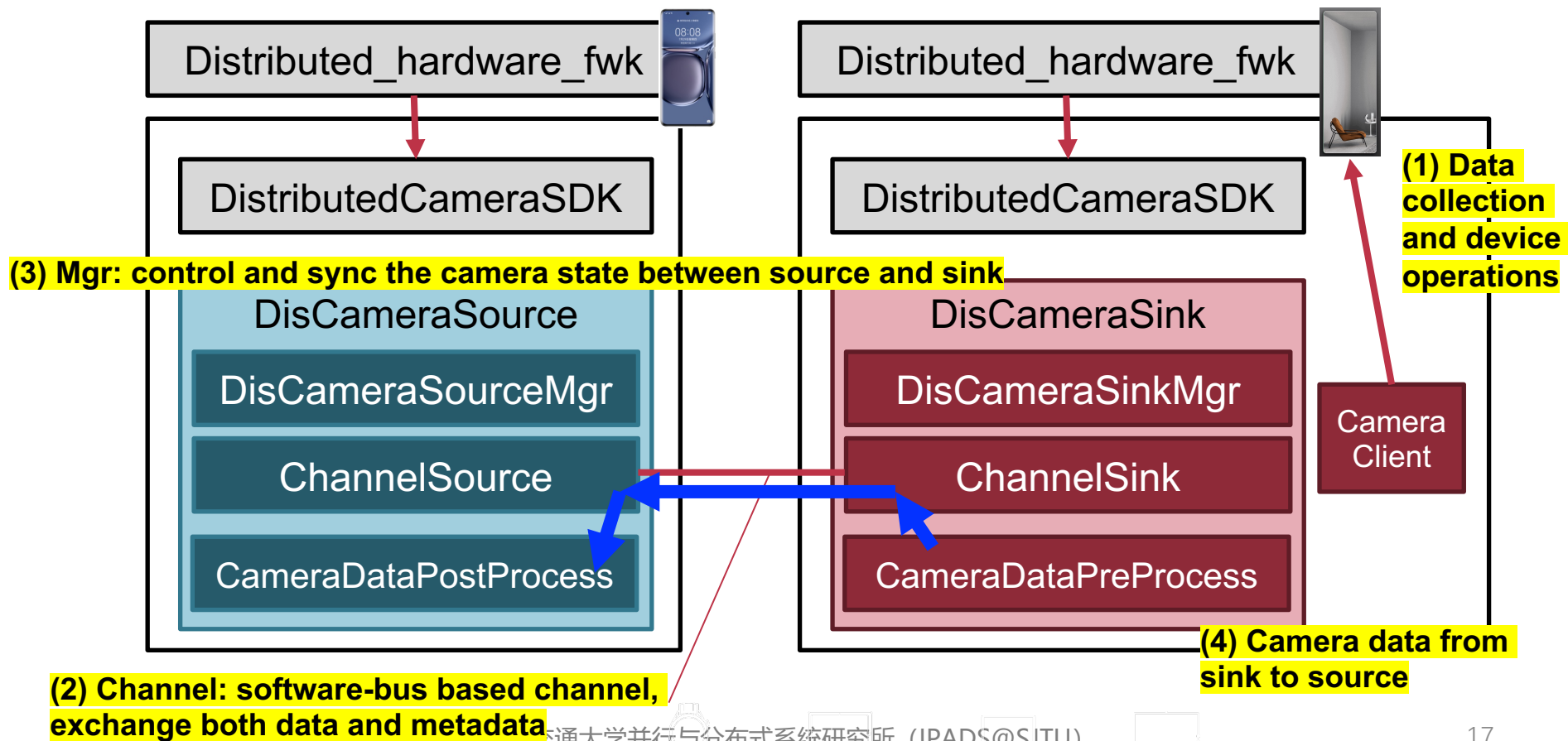


**(2) Channel: software-bus based channel, exchange both data and metadata**

# Distributed Hardware: Distributed Camera

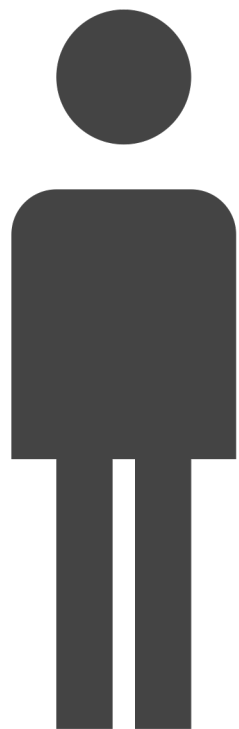


# Distributed Hardware: Distributed Camera





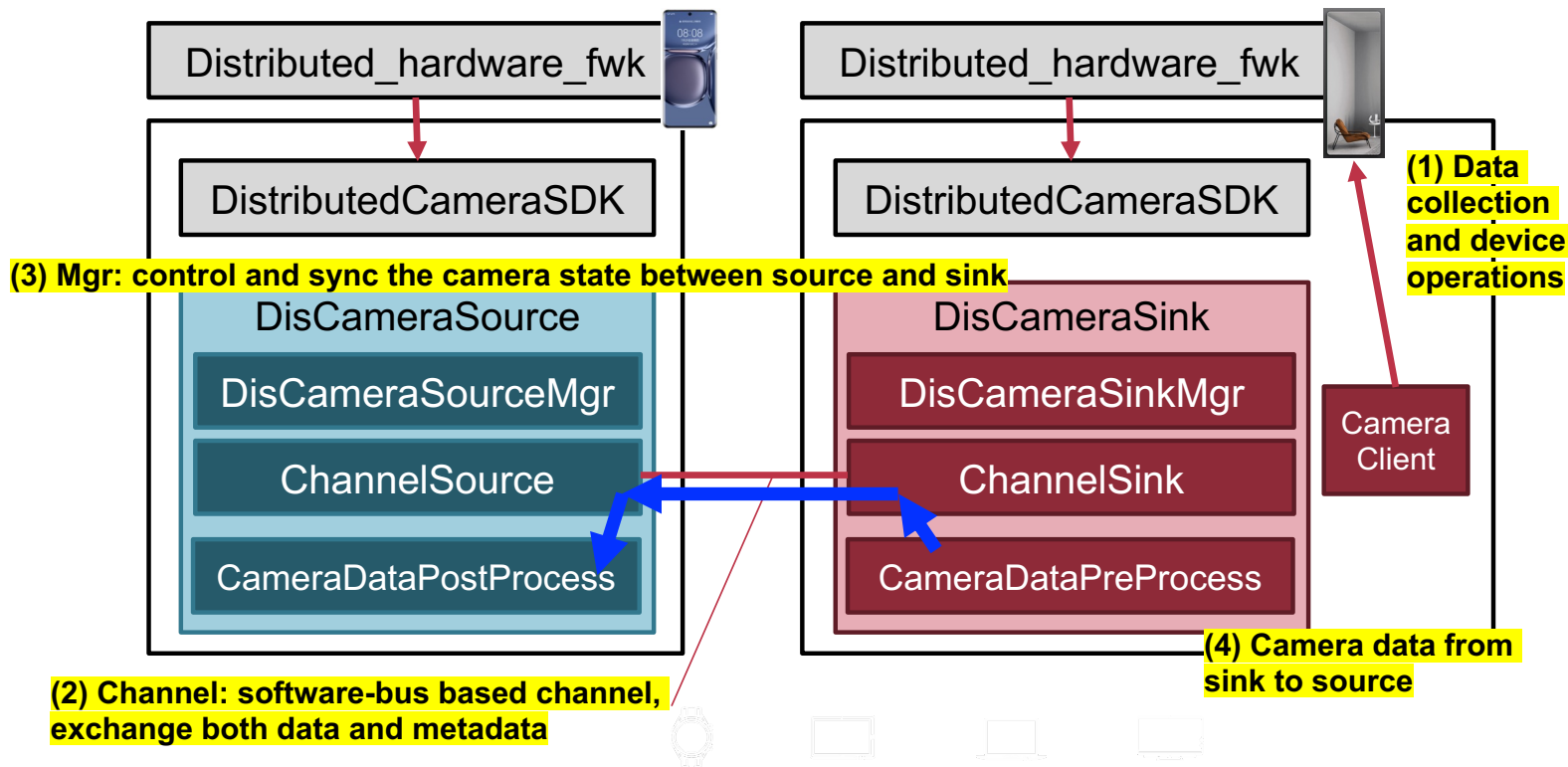
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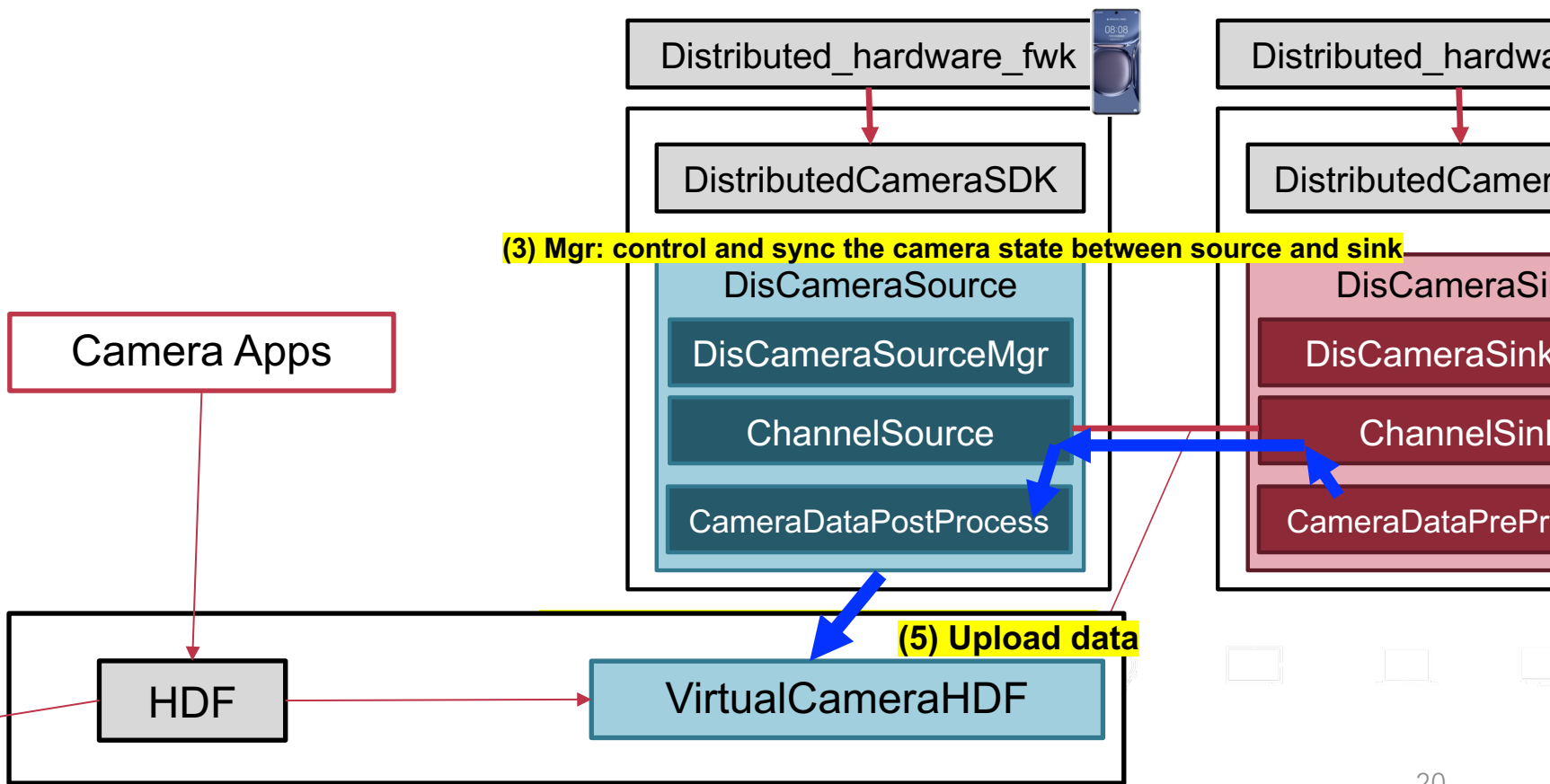
How can my Apps use the remote camera just like local ones?



# Distributed Hardware: Distributed Camera



# Distributed Hardware: Distributed Camera

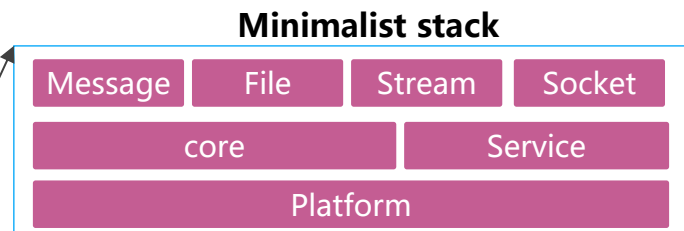
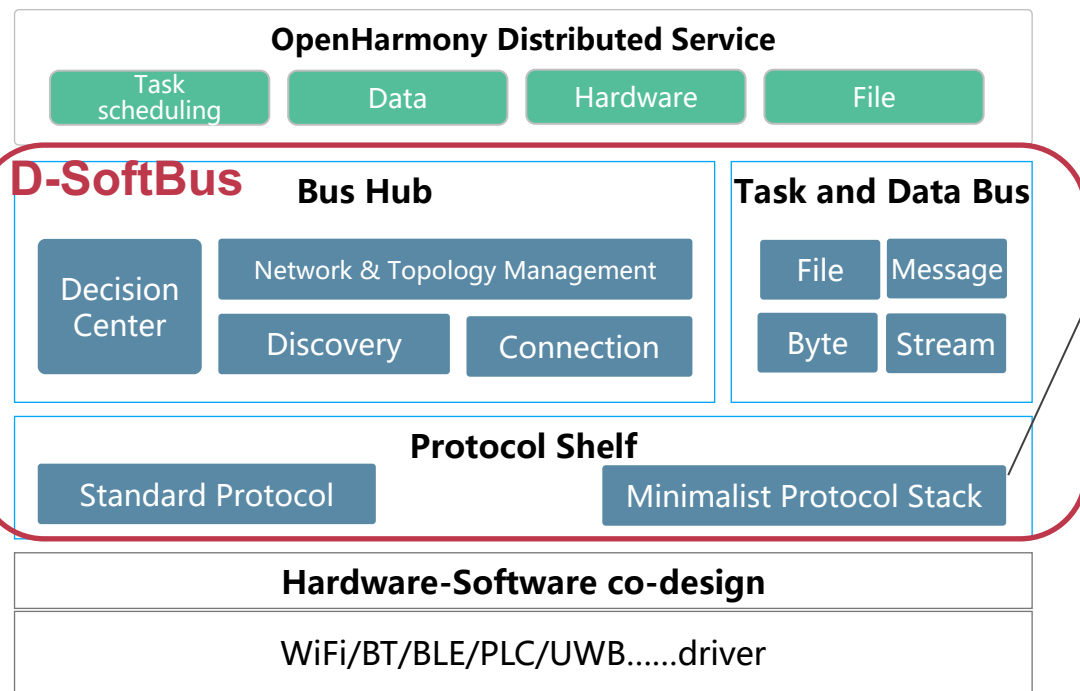




# DISTRIBUTED SOFT-BUS

# Distributed Soft-Bus

Distributed Soft Bus for **discovery**, **connection**, and **data transfer**, providing a real-time online connectivity channel for mobiles/IoT

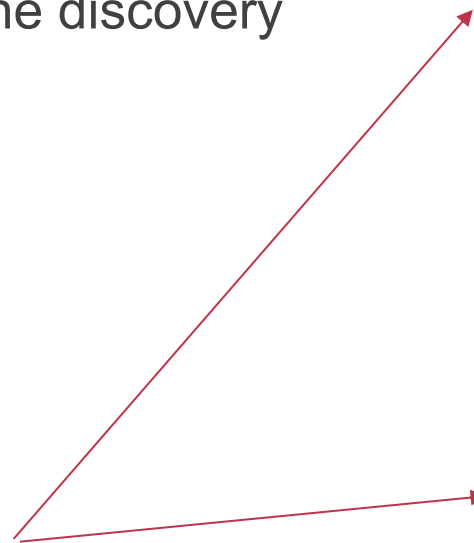


Eliminates **redundant header overhead**, leverages real-time MAC layer status to accurately sense **wireless network quality**, and adjusts packet transmission rate precisely

- **Compressed protocol layers**
- **Precision Congestion Control**
- **Chip Frequency Tuning/Energy Saving**

# D-SoftBus: Device Discovery

- **Phone**
  - Using specific protocol to broadcast the discovery request



# D-SoftBus: Discovery

- **Phone**

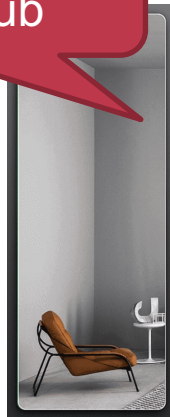
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- **Devices**

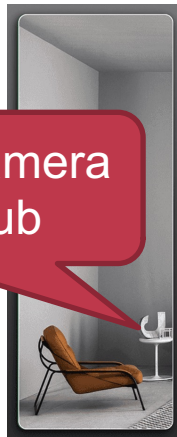
- Using pub/sub model to expose their services



My service is camera  
using Pub/Sub



My service is camera  
using Pub/Sub



# D-SoftBus: Discovery

- **Phone**

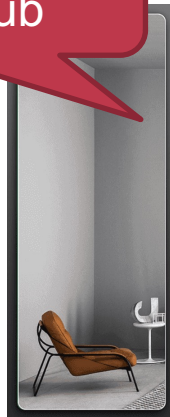
- Using specific protocol to broadcast the discovery request

- **Devices**

- Using pub/sub model to expose their services
- Ack the requests



My service is camera using Pub/Sub



My service is camera using Pub/Sub





# D-SoftBus: Discovery

- **Phone**

- Using specific protocol to broadcast the discovery request
- Update the D-SoftBus info

- **Devices**

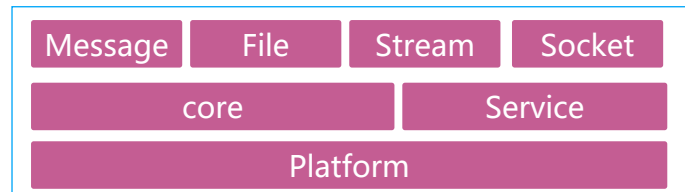
- Using pub/sub model to expose their services
- Ack the requests



# D-SoftBus: Transmission

- **Customized protocol**
  - Minimalist network stack
  - Other customizable (e.g., QUIC)
- **Multi-Path transport**
  - Utilize abilities of 4G/5G/WLAN/etc.
- **Intelligent latency control**
  - Optimize latency
- **Dynamic resource scheduling**

## Minimalist stack



Eliminates **redundant header overhead**, leverages real-time MAC layer status to accurately sense **wireless network quality**, and adjusts packet transmission rate precisely

- **Compressed protocol layers**
- **Precision Congestion Control**
- **Chip Frequency Tuning/Energy Saving**



# DISTRIBUTED DATA

# Distributed Data

- Different apps on the same device can share data
- Different apps on different devices can share data
- The same apps on different devices can share data
- Also provides management, reliability, and security related functionalities

# Distributed Data

## Support Features

Dist. Profile

Dist. Notification

Dist. Media

Business Migration

Collaboration

...

### Distributed data object

Basic Types

Array

Nested Objects

### Local/Distributed DB

Key Value

Relational

Preferences

### Cross-App Access

Database

File

### Security

Access control

Encryption

Tiering

### Management Services

Metadata

Lifecycle

Multi-user

Concurrency

Subscription

Synchronization

Resilience

### Storage

Relational

Index

Schema

xml

Disk/  
Mem

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Conflict  
Resolution

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Automatic

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## Dist. data management

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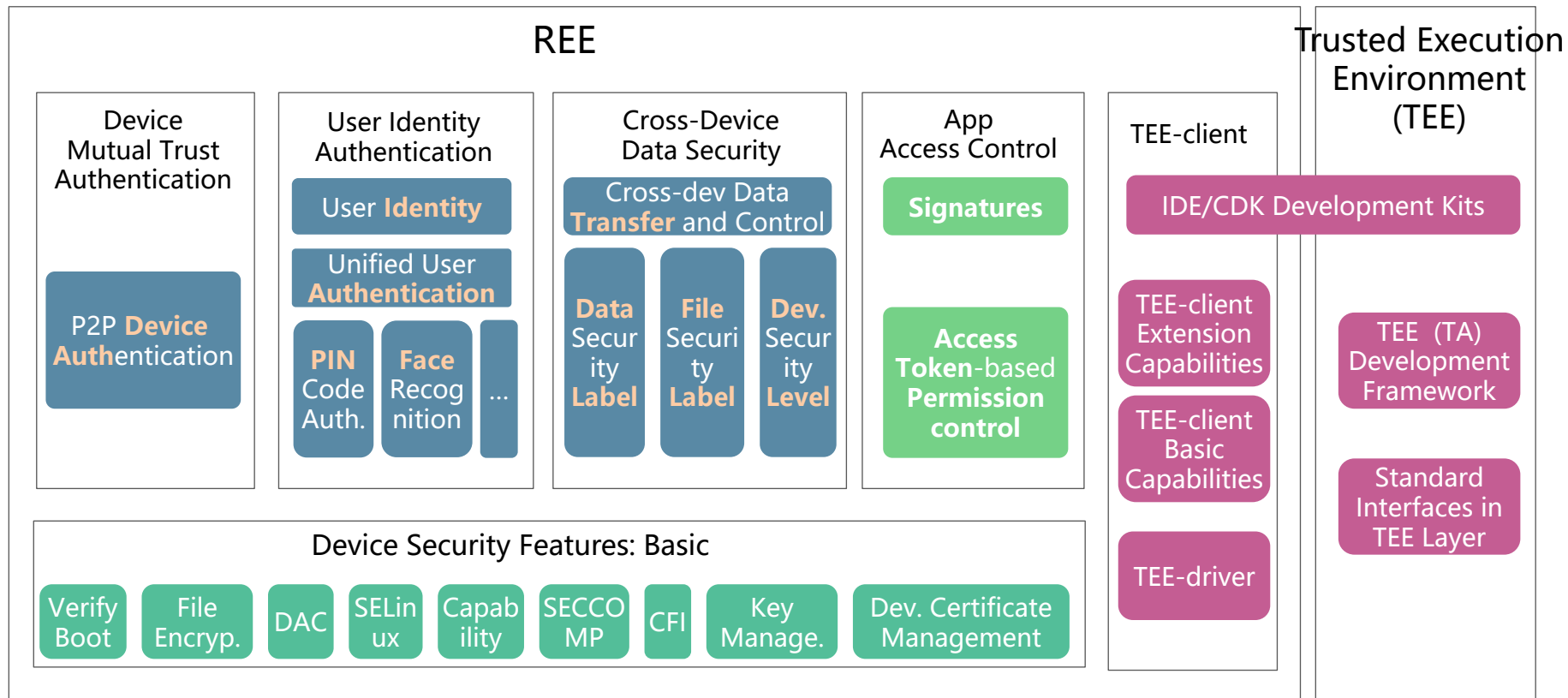


# DISTRIBUTED SECURITY

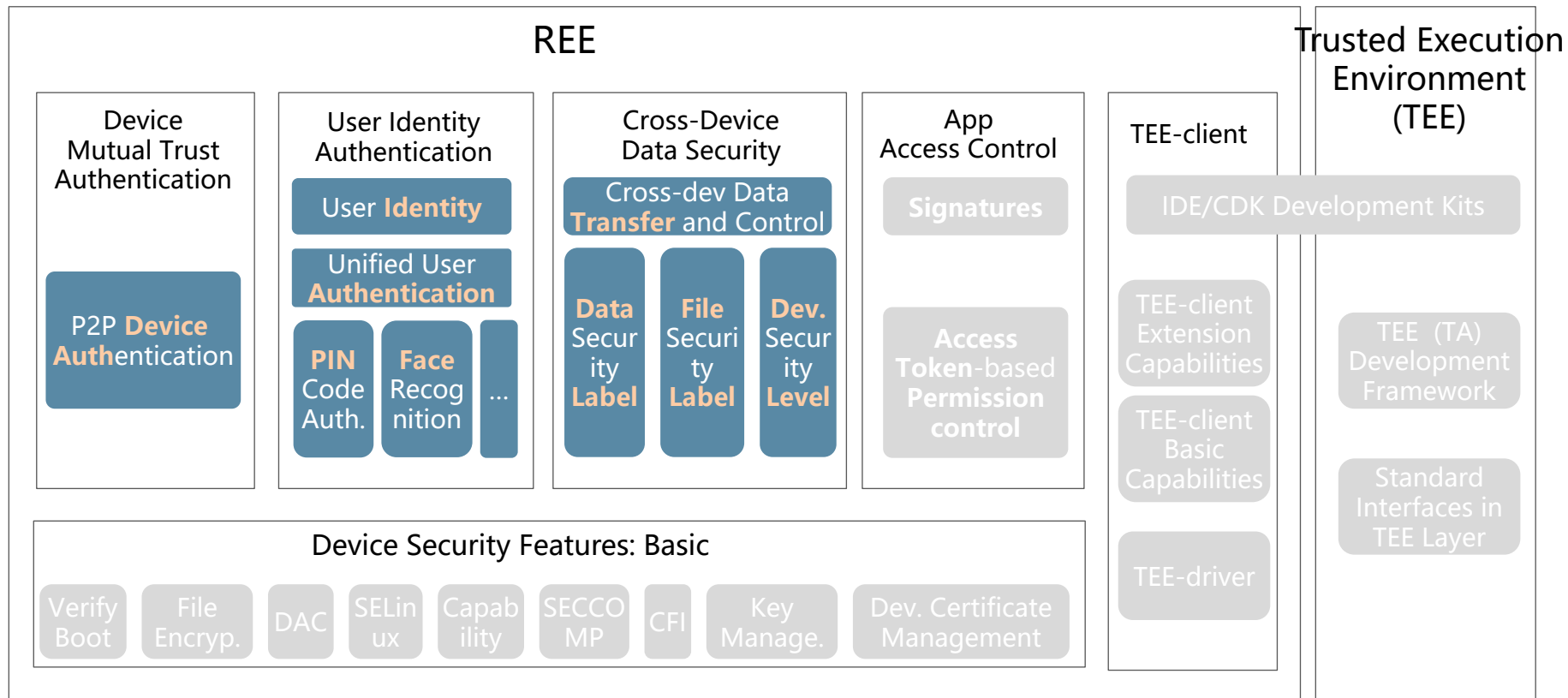
# Security: From Single to Distributed OS

- **Multi-device network and the authentication**
- **Access control is basic for a single OS, how it works for multi-dev and multi-OS**
- **Trusted execution environment (TEE)**

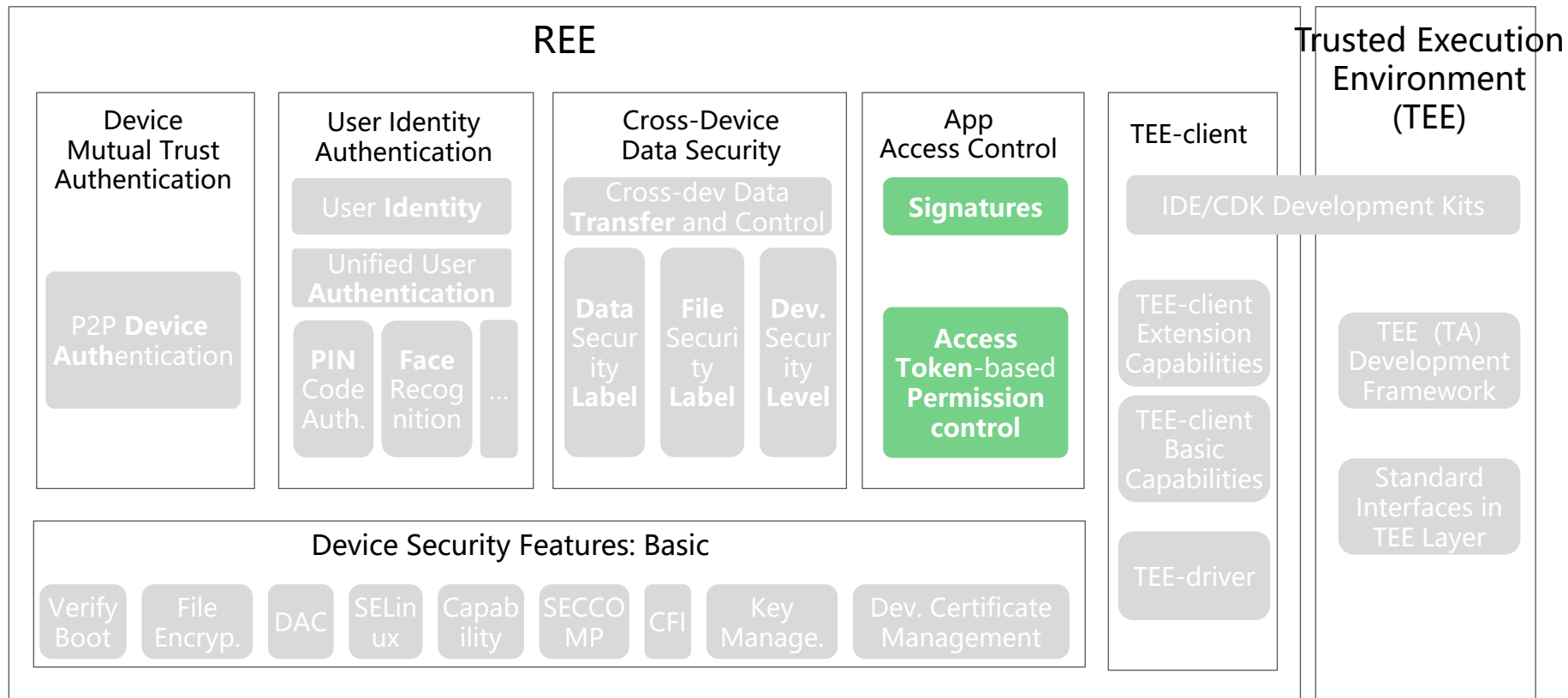
# Distributed Security Framework



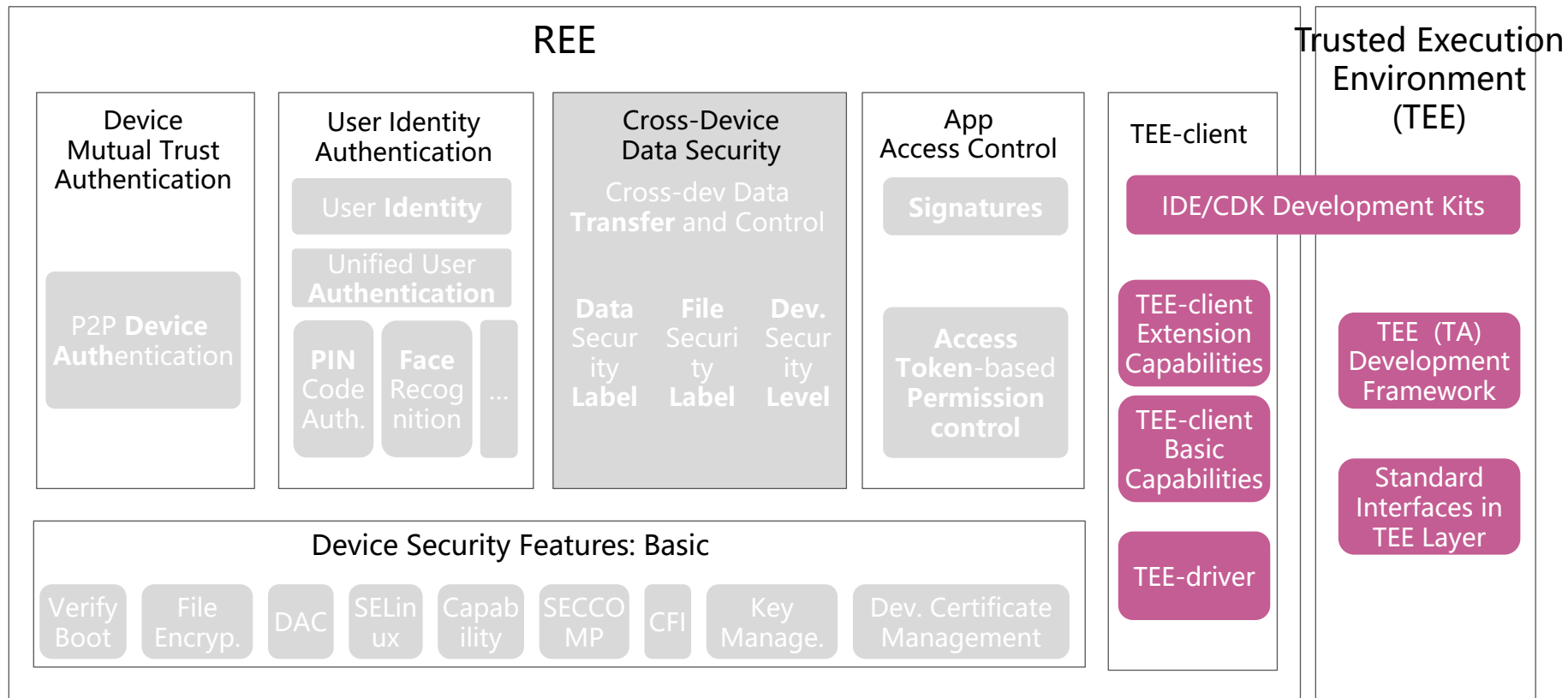
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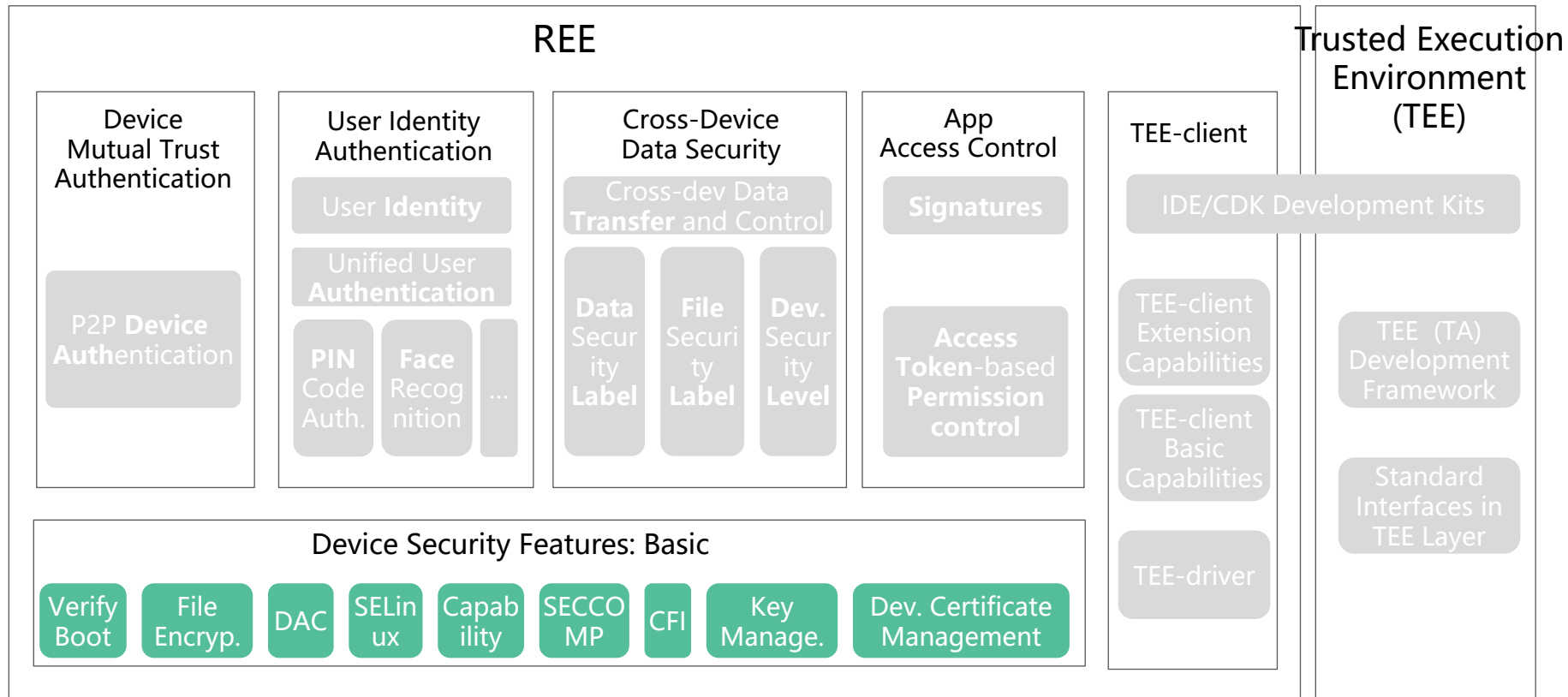
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# Distributed Security Framework





# Summary

Feel free to contact me: [dd\\_nirvana@sjtu.edu.cn](mailto:dd_nirvana@sjtu.edu.cn)

- **OpenHarmony takes distribution as the first-class capability**
  - Distributed hardware
  - Software bus
  - Distributed data
  - Distributed security
- **Try the **exercise/demo** in following talk/sessions ☺**
  - How to build and run **distributed apps** that can migrate from two devices and share data
  - **Vsync** Demo (**ASPLOS'21 distinguished paper**)
  - In the last demo, we will show how **TEE is distributed**