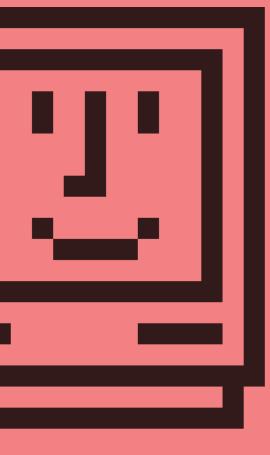
# CS530 Operating System Preparing Next Mobile Explosion : a glimpse of multi-device operating system



TEAM #7Youngjae Chang youngjae.chang@kaist.ac.krTae Gyeong Lee danny003@kaist.ac.kr

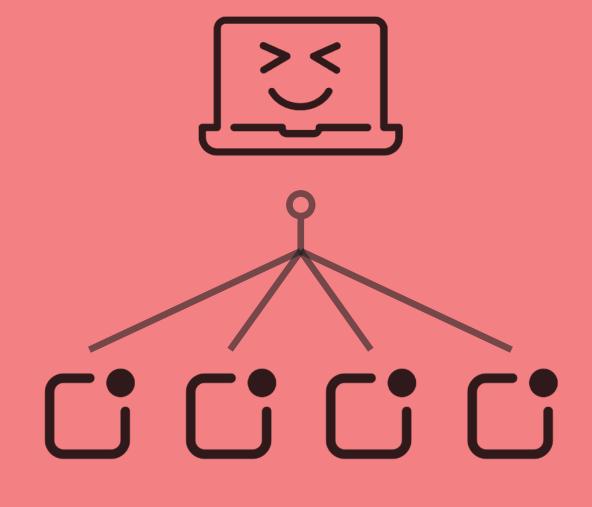
### Early 2000's

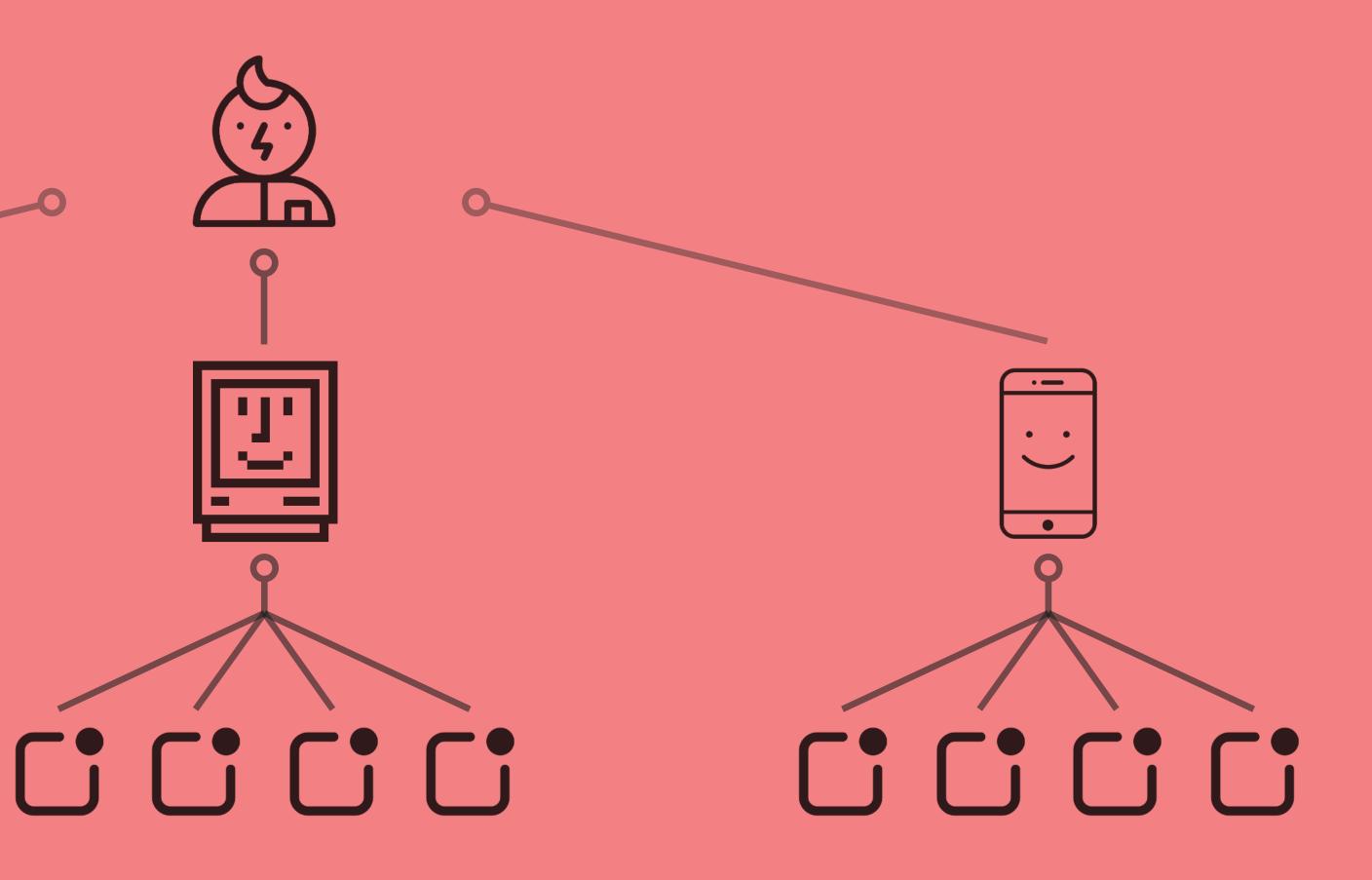


### Met a computer



2







# We have ... Multiple devices !

### / / / / /



### How's your experience?

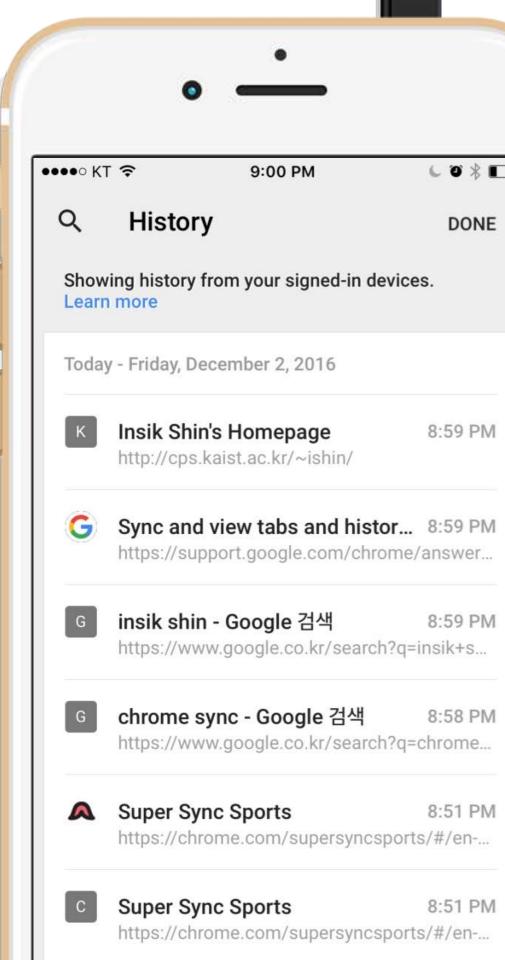
### Platform arose from examples!



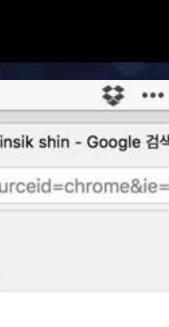
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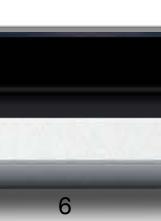


### I. Chrome



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	검색결과 약 67,800개 (0.45초)	
	Insik Shin's Homepage - CPS Lab KAIST cps.kaist.ac.kr/~ishin/ - 이 페이지 번역하기 Insik Shin is an associate professor in the Department of Computer Science at KAIST, Korea. He receive Ph.D. degree from the University of Pennsylvania,	d a
PM C * * C DONE	Insik Shin - KAIST School of Computing, 카이스트 전산학부 - 컴퓨터 https://cs.kaist.ac.kr/people/view?idx=15&kind=faculty&menu=167 マ Insik Shin is currently an associate professor in Dept. of Computer Science at KAIST, since 2008. He rec a B.S. from Korea University, an M.S. from	ceived
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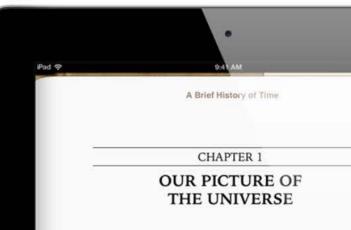
### 2. Dropbox







### **3. iBooks**



clever," said the old lady. "But it's turtles all the way down!" orbiting the sun—or perhaps as ridiculous as a tower of tortois-es. Only time (whatever that may be) will tell. As long ago as 340 BC the Greek philosopher Aristotle, in his

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CHAPTER 1

OUR PICTURE OF

THE UNIVERSE

A well-known scientist (some say it was Bertrand Russell)

how the sun, in turn, orbits

tars called our galaxy. At the end the lecture, a little old lady at the

back of the room got up and said is really a flat plate sur

public lecture o omy. He described how the nd the sun and

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A well-known scientist (some say it was Bertrand Russell) once gave a public lecture on astronomy. He described how the earth orbits around the sun and how the sun, in turn, orbits around the center of a vast collection of stars called our galaxy. At the end of the lecture, a little old lady at the back of the room got up and said: "What you have told us is rubbish. The world is really a flat plate supported on the back of a giant tortoise." The scientist gave a superior smile before replying, "What is the tortoise standing on?" "You're very clever, young man, very

Most people would find the picture of our universe as an infinite tower of tortoises rather ridiculous, but why do we think we know better? What do we know about the universe, and how do we know it? Where did the universe come from, and where is it going? Did the universe have a beginning, and if so, what happened before then? What is the nature of time? Will it ever come to an end? Can we go back in time? Recent breakthroughs in physics, made possible in part by fantastic new technologies, suggest answers to some of these longstanding questions. Someday these answers may seem as obvious to us as the earth

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000 A Brief History of Time CHAPTER 1 **OUR PICTURE OF** THE UNIVERSE well-known scientist (some say it was A Bertrand Russell) once gave a public lecture on astronomy. He described how the earth orbits around the sun and how the sun, in turn, orbits around the center of a vast collection of stars called our galaxy. At the end

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Most people would find the picture of our universe as an infinite tower of tortoises rather ridiculous, but why do we think we know better? What do we know about the universe, and how do we know it? Where did the universe come from, and where is it going? Did the universe have a beginning, and if so, what happened before then? What is the nature of time? Will it ever come to an end? Can we go back in time? Recent breakthroughs in physics, made possible in part by fantastic new technologies, suggest answers to some of these longstanding questions. Someday these answers may seem as obvious to us as the earth orbiting the sun-or perhaps as ridiculous as a tower of tortoises. Only time (whatever that may be) will tell. As long ago as 340 B.C. the Greek philosopher Aristotle, in his book On the Heavens, was able to put forward two good arguments for believing that the earth was a round sphere rather than a flat plate. First, he realized that eclipses of the moon were caused by the earth coming between the sun and the moon. The earth's shadow on

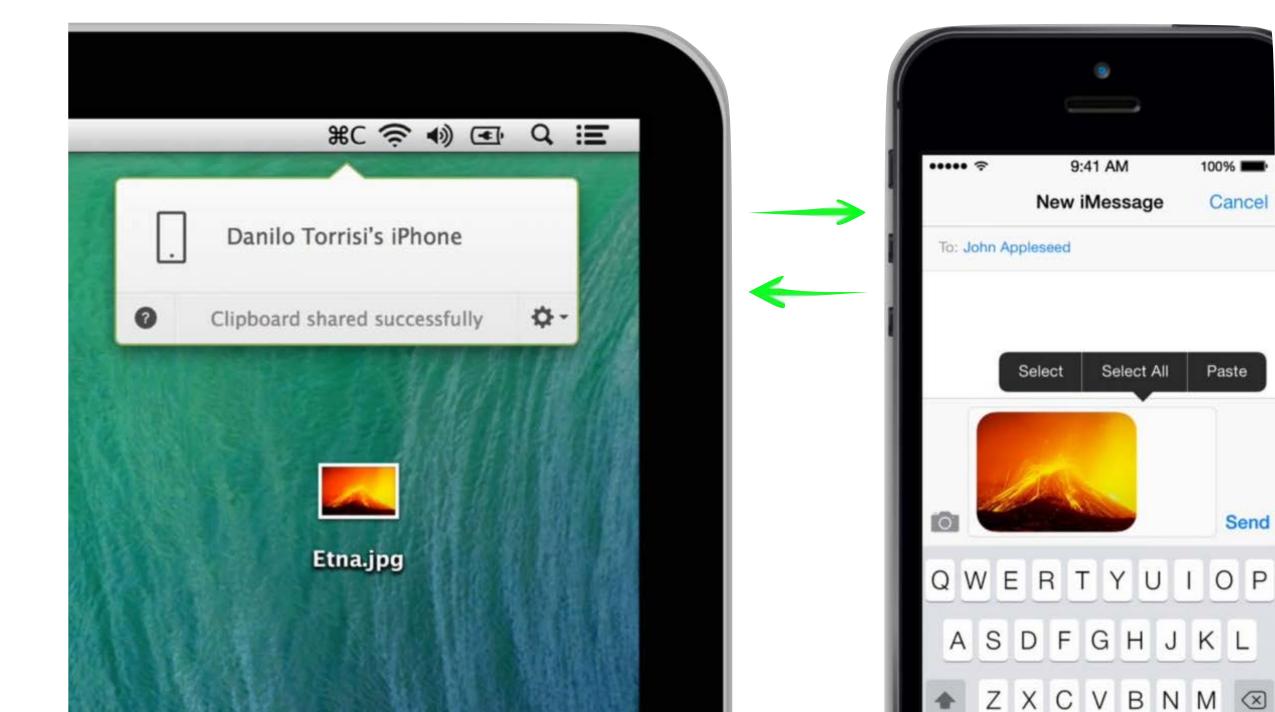
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### 4. Clipboard Sharing





### 5. Typing on TV





### 6. Handoff Calling



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### 7. Video Encoding



#### mkv → mp4

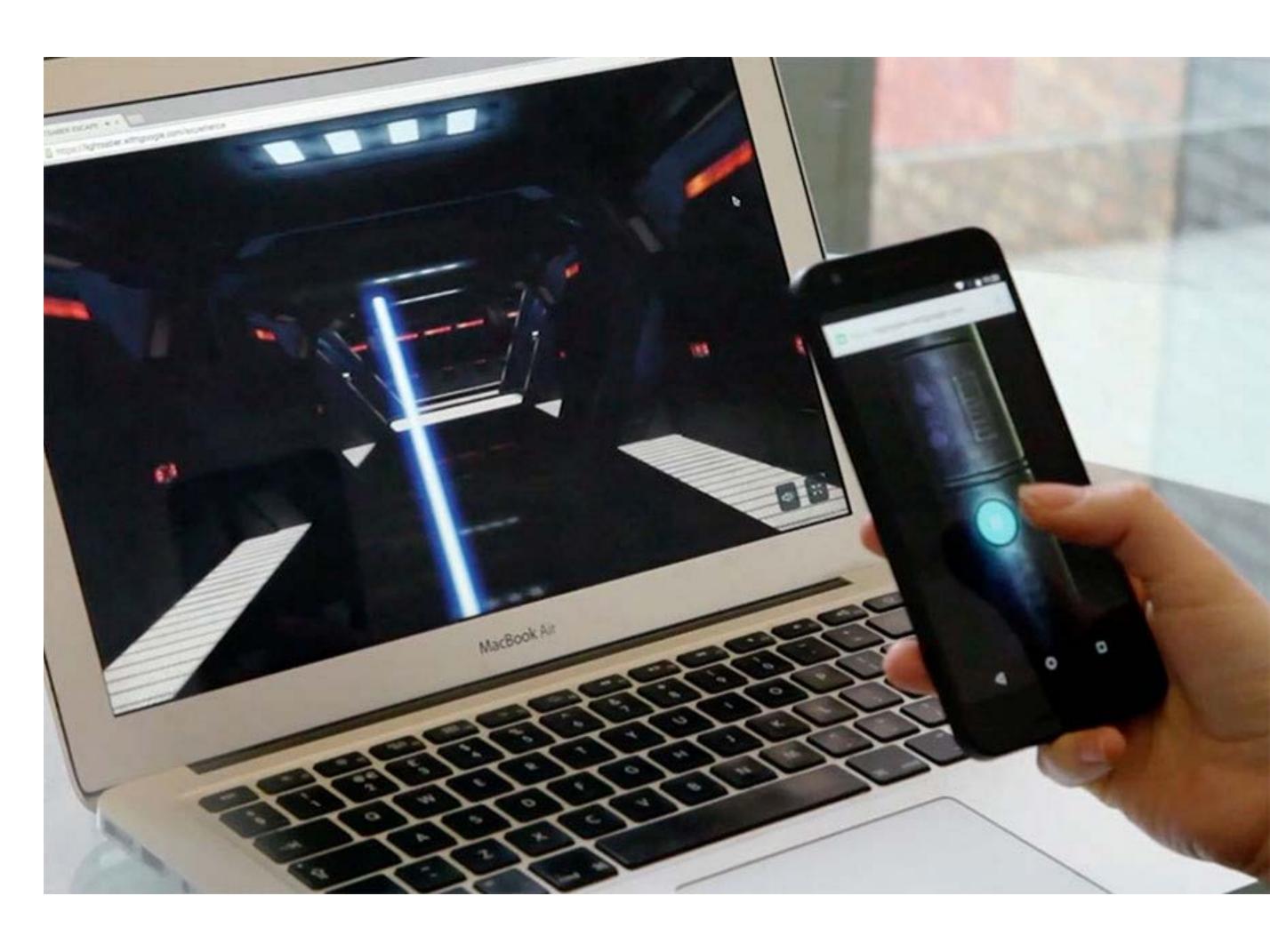








### 8. Smartphone as a joystick!





# 

# 66 A computer on every desk, and in every home. — Bill Gates



### 66 It's a world of multiple screens, smart displays, with tons of low-cost computing, with big sensors built into devices.

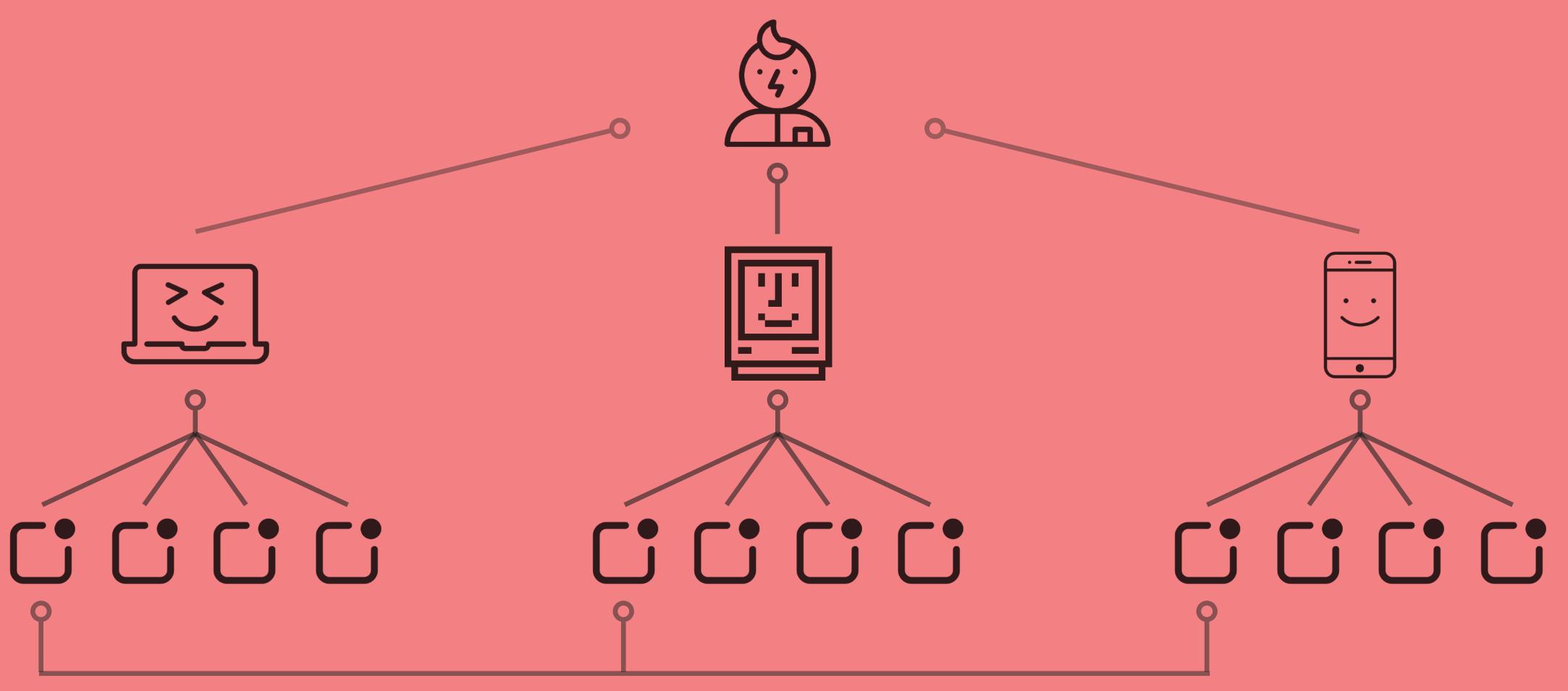
— Sundar Pichai



### At Google, we ask how to bring together something seamless and beautiful and intuitive across all these screens.

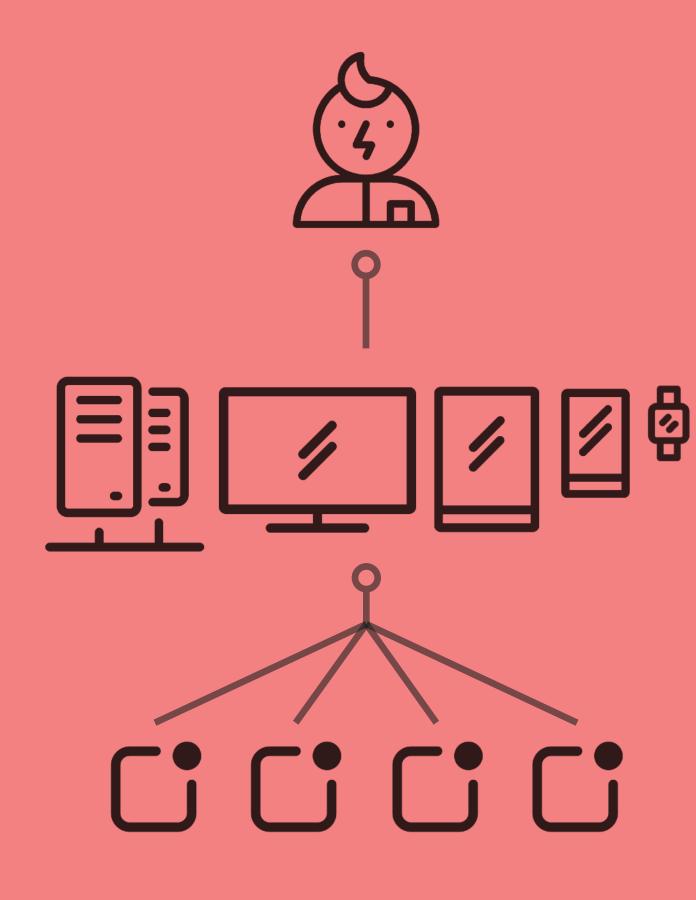


#### Same app; build it 3 times?





#### **Multi-Device Operating System**



#### What are the **Requirements?**

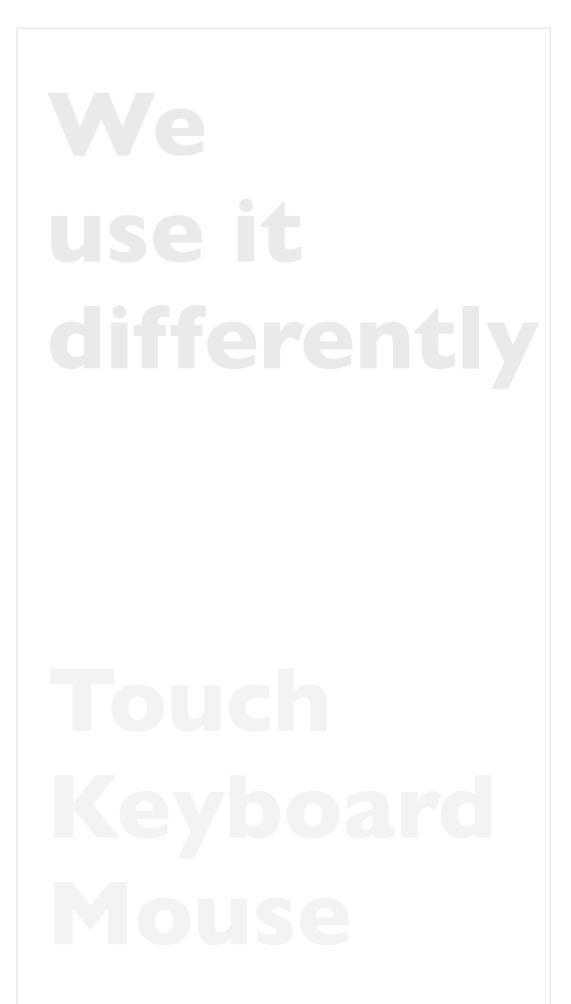


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We expect same experience

Sync, sync, **Sync** 











We expect same experienc

Sync, Sync, Sync

### We want the most of all my HW

### Desktop helping phone





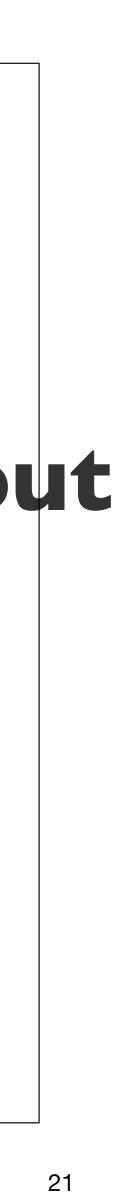


We expect same experienc

Sync, Sync, Sync

### we want the most of all my HW

Desktop helping phone We do not want to worry about privacy







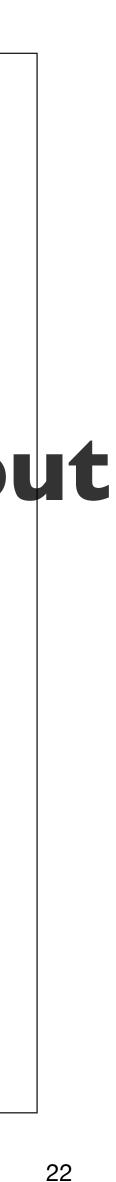
We expect same experience

Sync, sync, sync

### We want the most of all my HW

### Desktop helping phone

We do not want to worry about privacy



### I. Responsive User Interface

2. App State Sync

### 3. Resource Sharing

4. Privacy

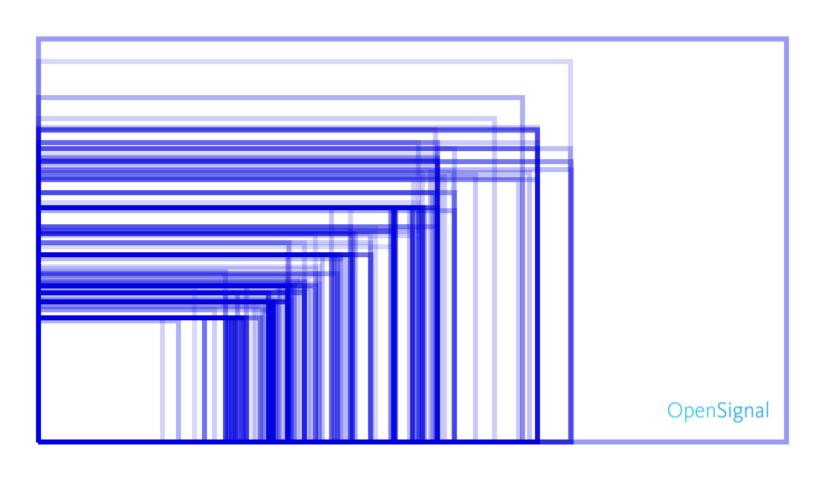




### I. Responsive User Interface

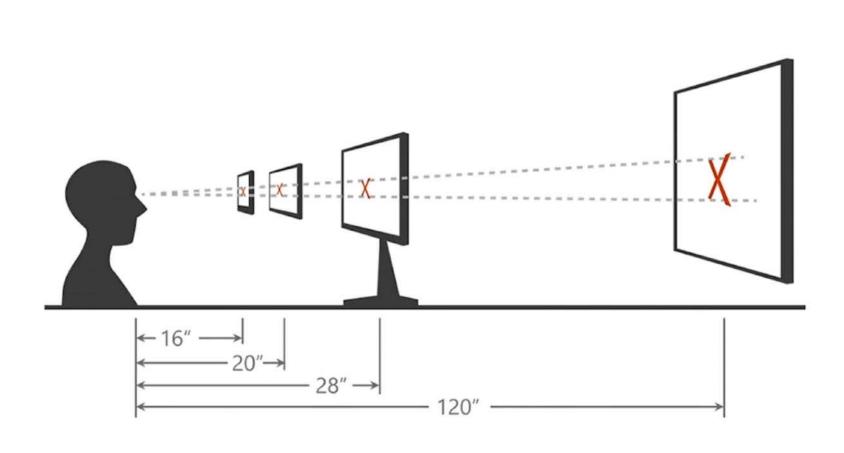
### Devices require various UI

- Different Screen Size
- Different Input H/W: Touch Screen / Mouse / Pen / Keyboard

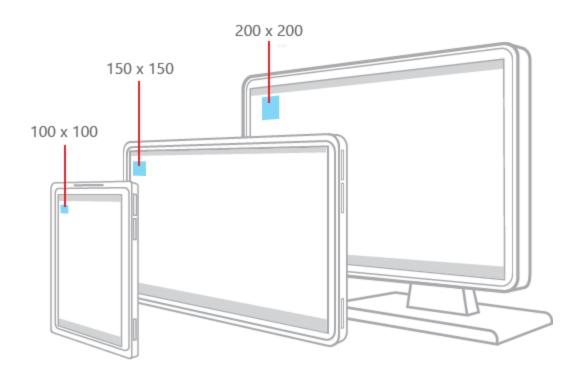




Responsive User Interface









### 2. App State Sync

- App components are divided or replicated and distributed in multiple devices
- Single app runs on multiple devices • Users try to use an app in multiple device concurrently

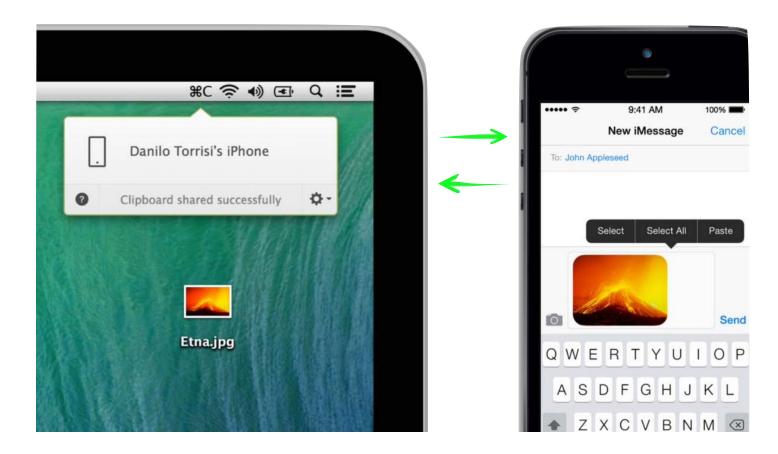


# 2. App State Sync



### File Data





App State



### 3. Resource Sharing

- - constraints limiting its computation power
- different sensors

### **Devices have different capability &** Some devices are busy while others are idle Mobile devices have intense physical

All devices are not created equal:



3. Resource Sharing





### computation

### sensor I/O





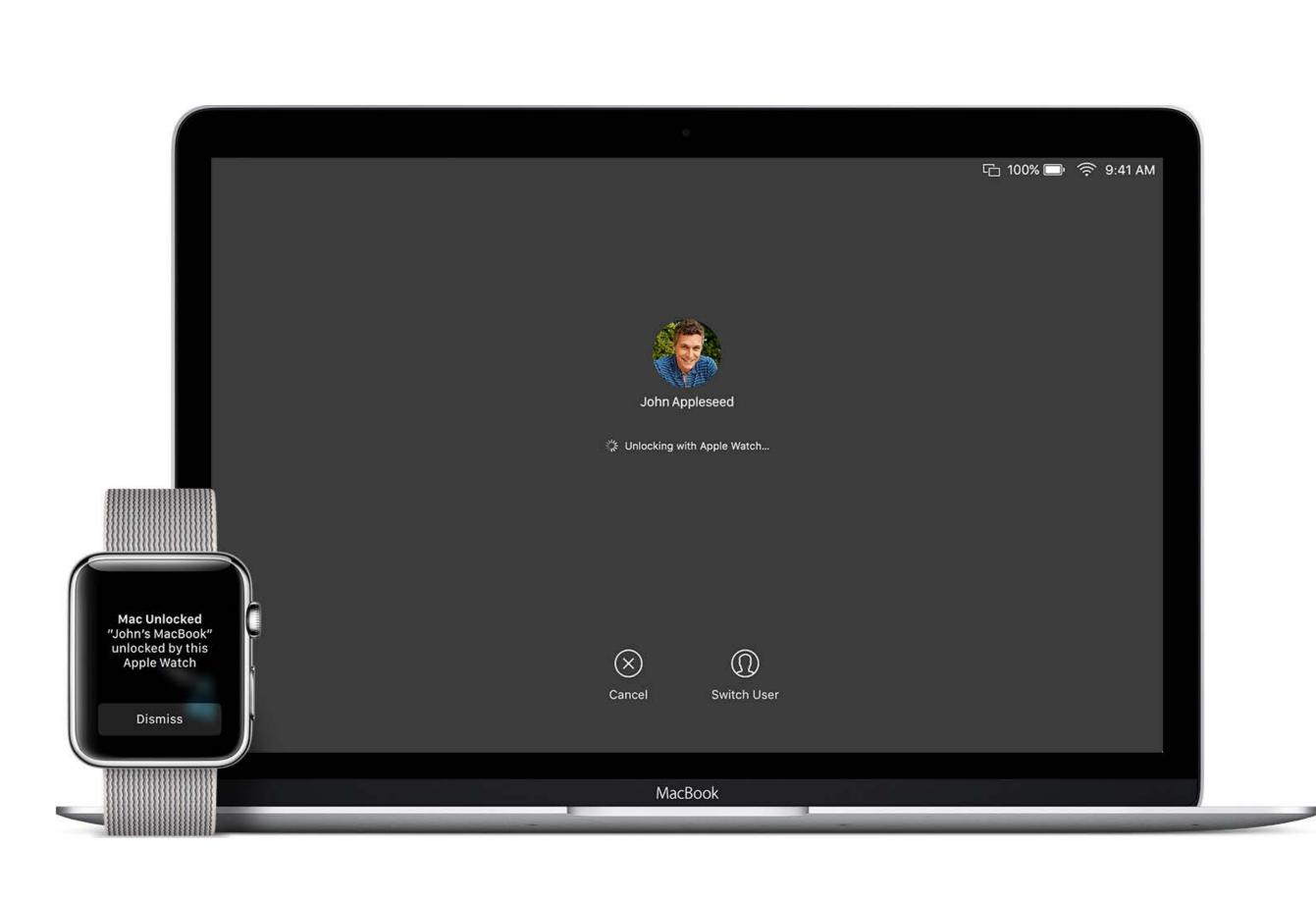
Unlocking macbook when wearing apple watch

Password synchronization on Chrome

### Single identity across multiple devices Korean people having hard time conducting online payment Data should have different privacy level, based on its content







### unlock Mac with Apple Watch

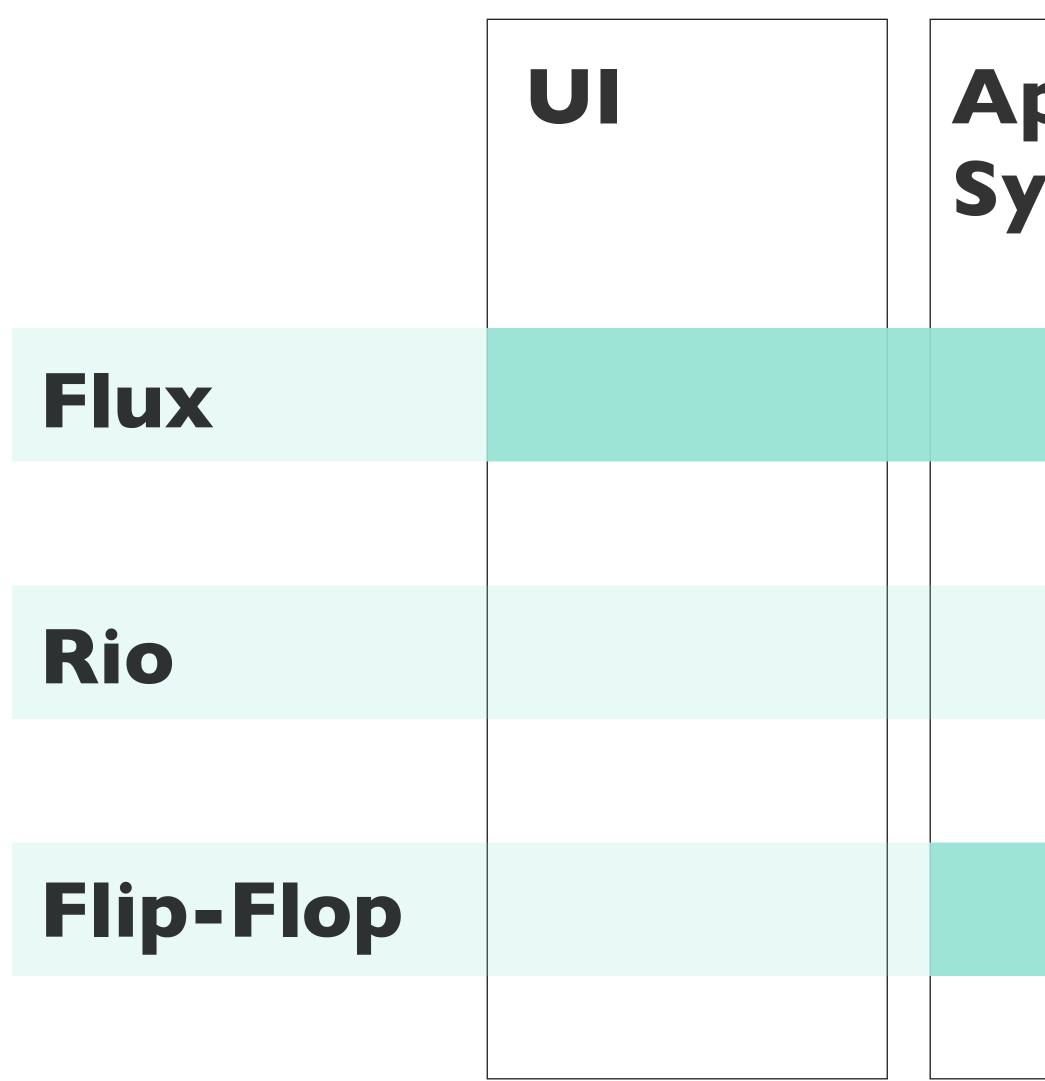












pp nc	Resource Sharing	Privacy



#### Case Study: Challenges

# Device Heterogeneity

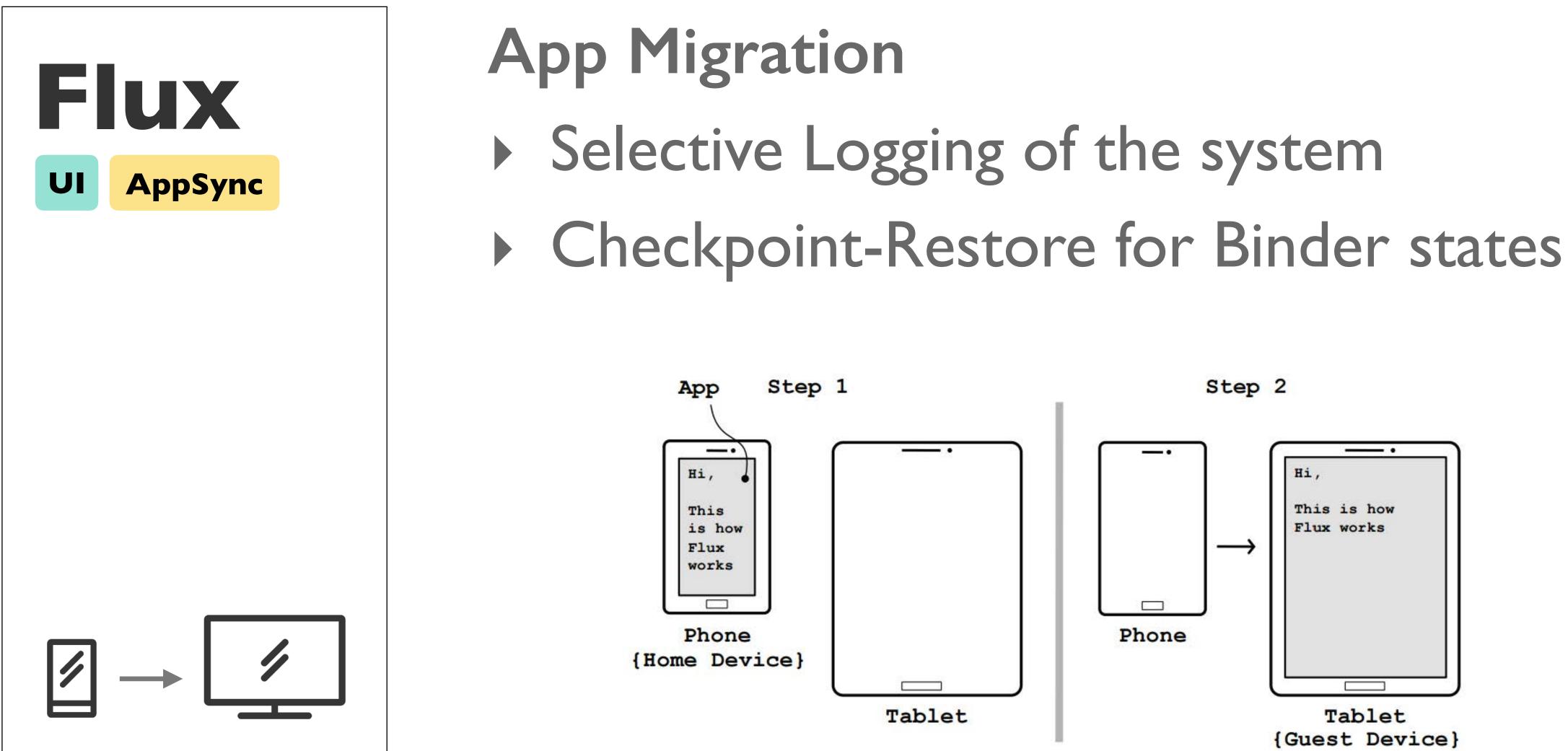
### ISA, GPU, I/O Devices, Screen Size Operating System



### RTT Connection Failure Congestion

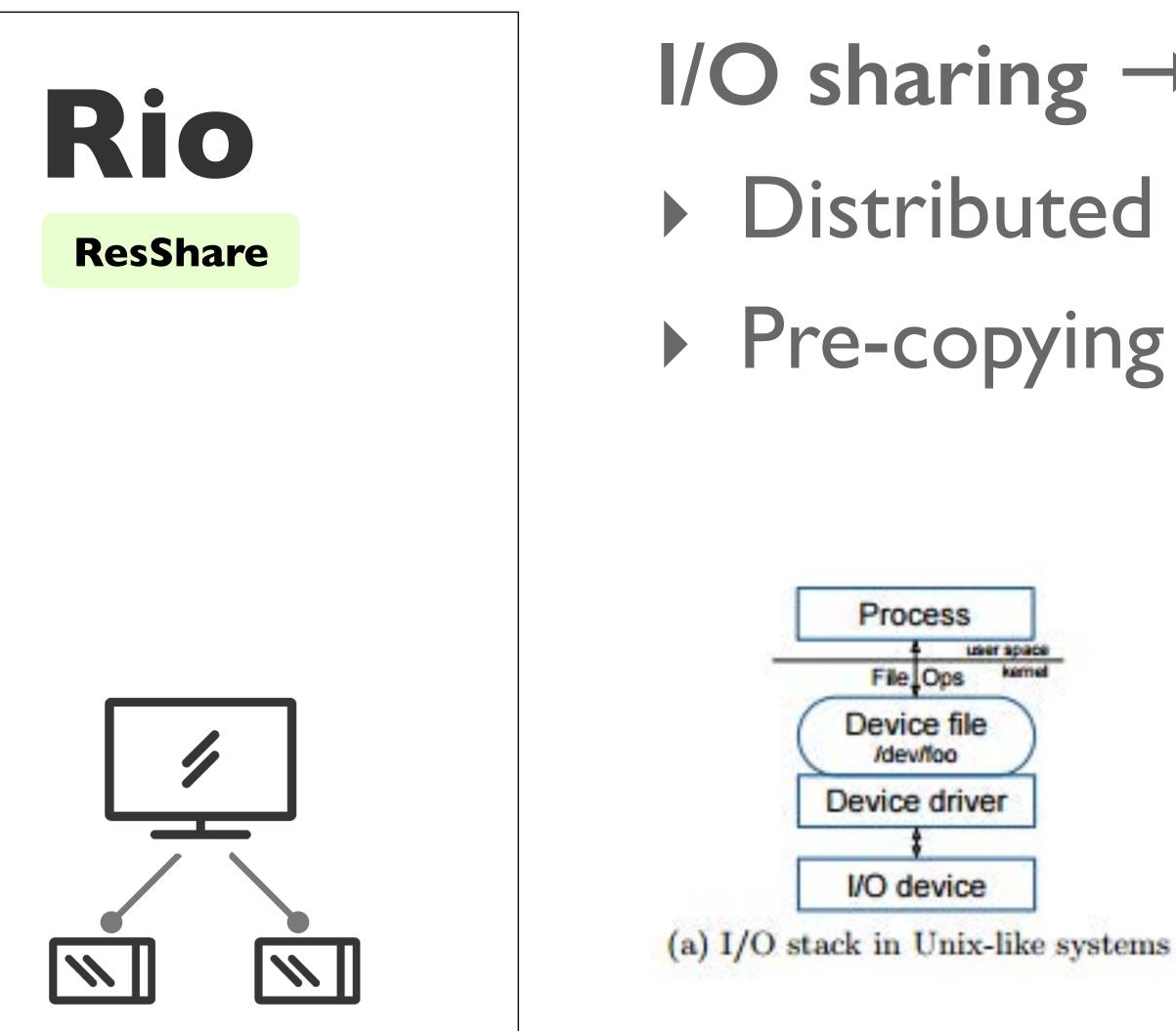




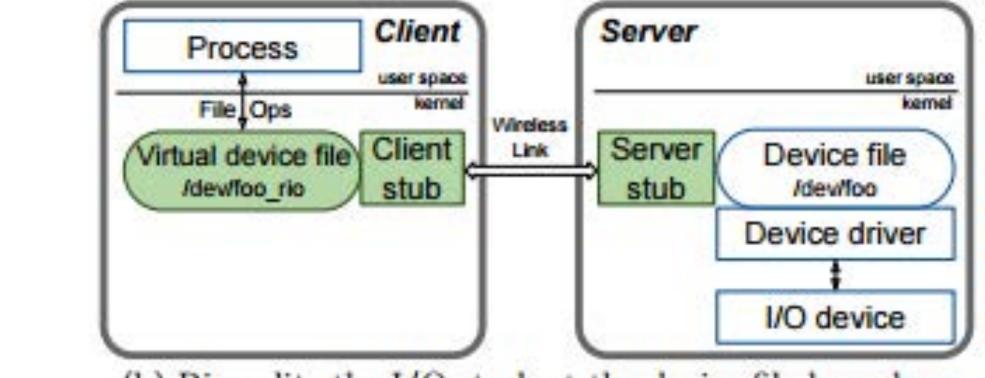




#### Case Study: Rio



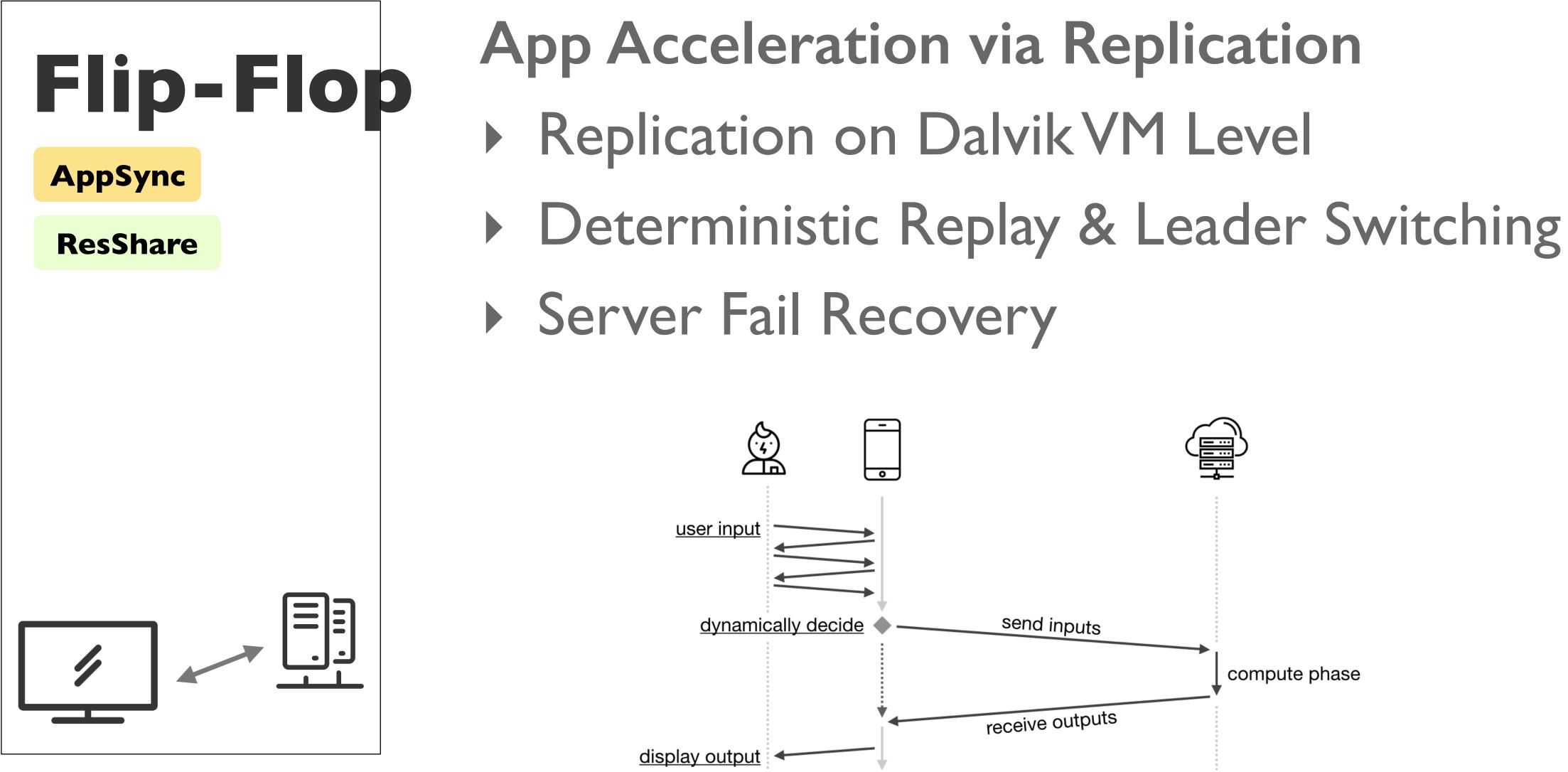
### I/O sharing $\rightarrow$ Virtual device file Distributed Shared Memory Pre-copying & Batching



(b) Rio splits the I/O stack at the device file boundary.

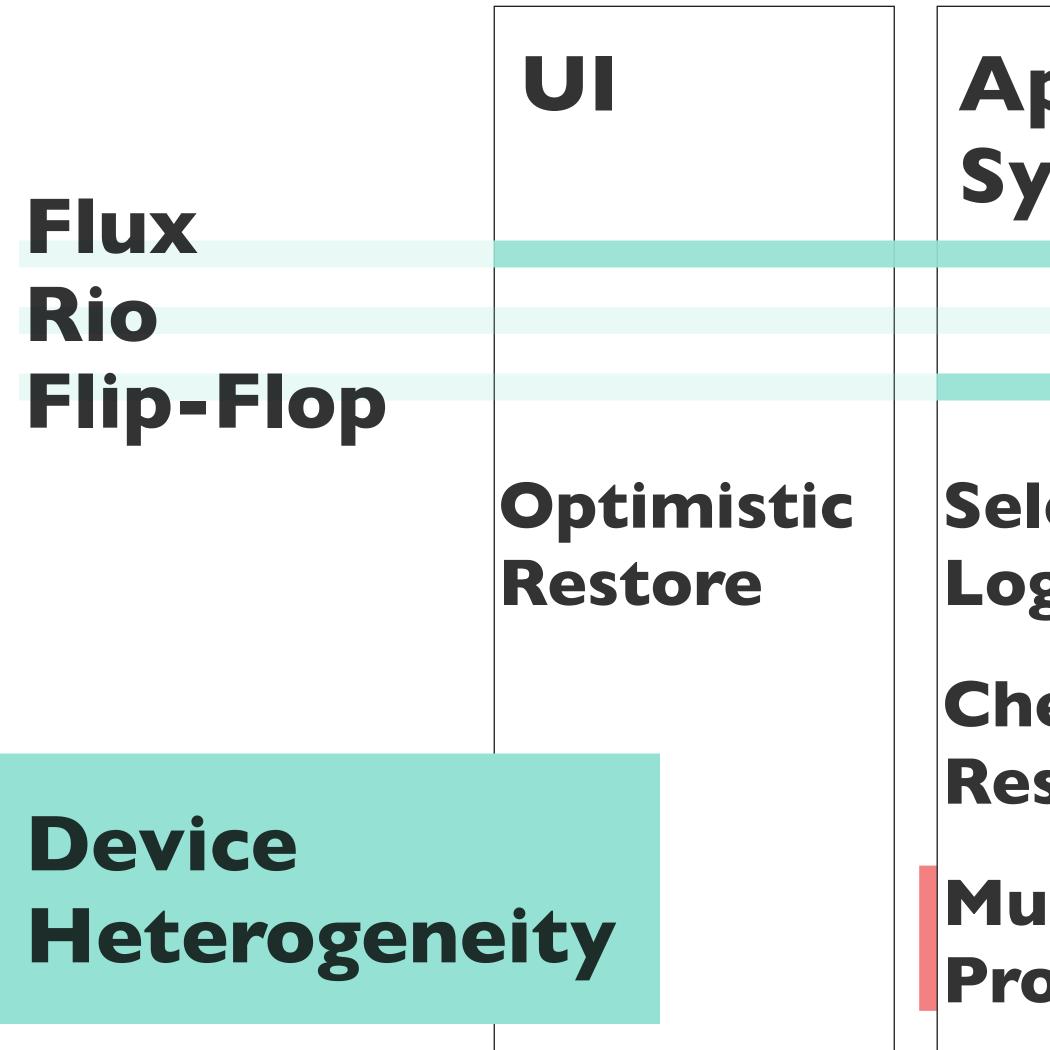


#### Case Study: Flip-Flop





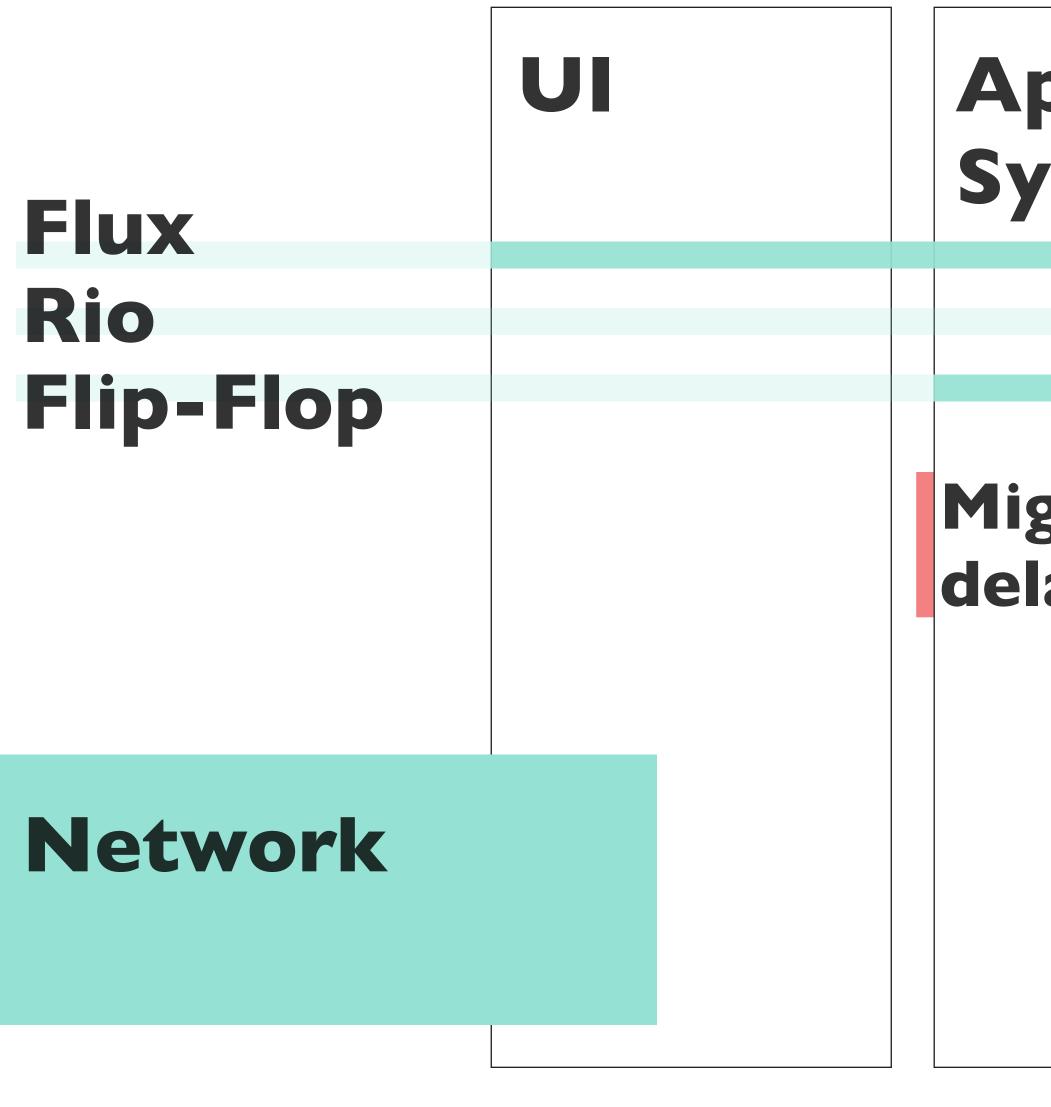
#### Case Study: Summary



	Resource         Sharing	Privacy
lective gging eckpoint	I/O share vi virtual device file	
store Ilti- ocess	Complete Replication Application	



#### Case Study: Summary



pp /nc	<section-header></section-header>	Privacy
gration lay	Network Acceleration	
	Bandwidth Problem	



Future Directions





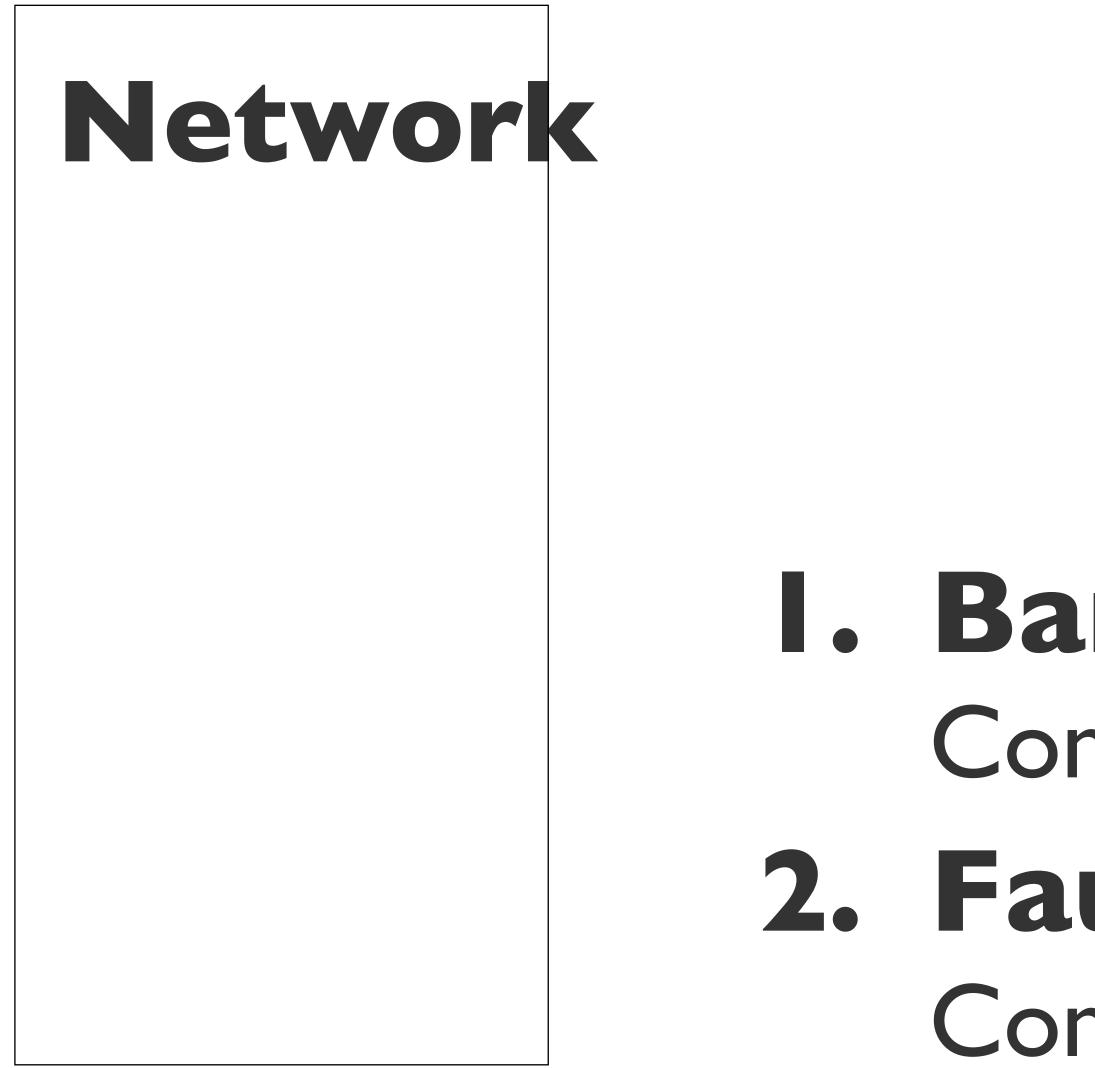
# Device Heterogeneity

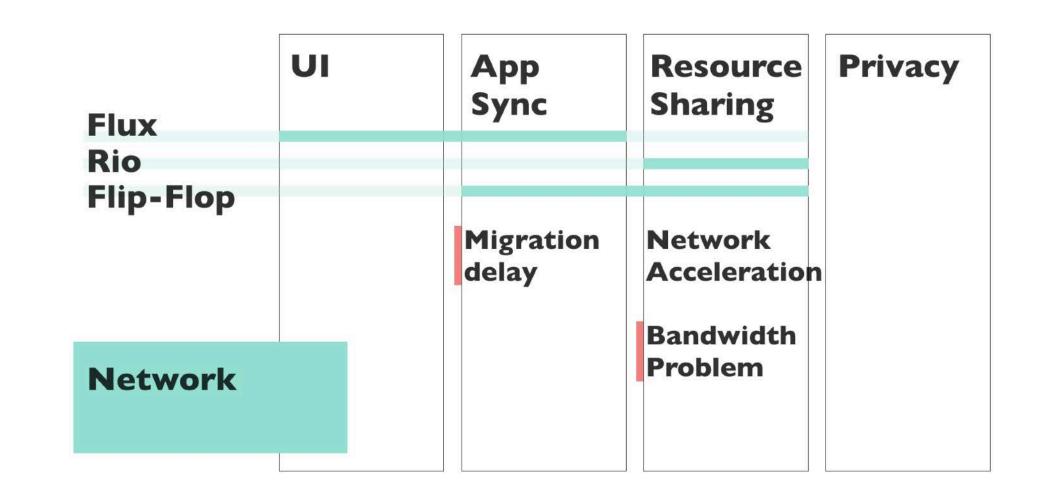
Flux Rio	UI		App Sync	Resource Sharing	Privacy
Flip-Flop	Opti Rest	mistic ore	Selective Logging Checkpoint	I/O share via virtual device file	
Device Heterogen	eity		Restore Multi- Process	Complete Replication of Application	of

### I. Non-determinism 2. Multi-Process



#### **Future Directions**





# I. Bandwidth Compression / Congestion 2. Fault Tolerance Complicate policy needed



#### **Future Directions**

# Privacy detection

I. Adaptive privacy policy i.e. proximity, authentication strategy

2. Intelligent private-info i.e. one-time GPS call v.s. frequent GPS call







