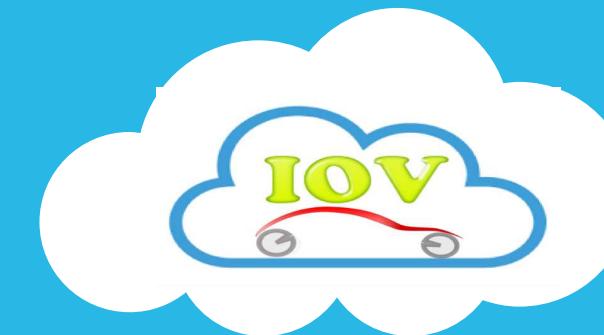




IEEE SC2 2018



IOV 2018



IEEE SOCA 2018

Liquid Software in a Programmable World

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Programmable Web

Programmable Web

Programmable Money

Programmable Web
Programmable Money
Programmable World



Every Thing is
Connected





IROBOT

now

Roomba requires your attention
Clear Roomba's main brushes.

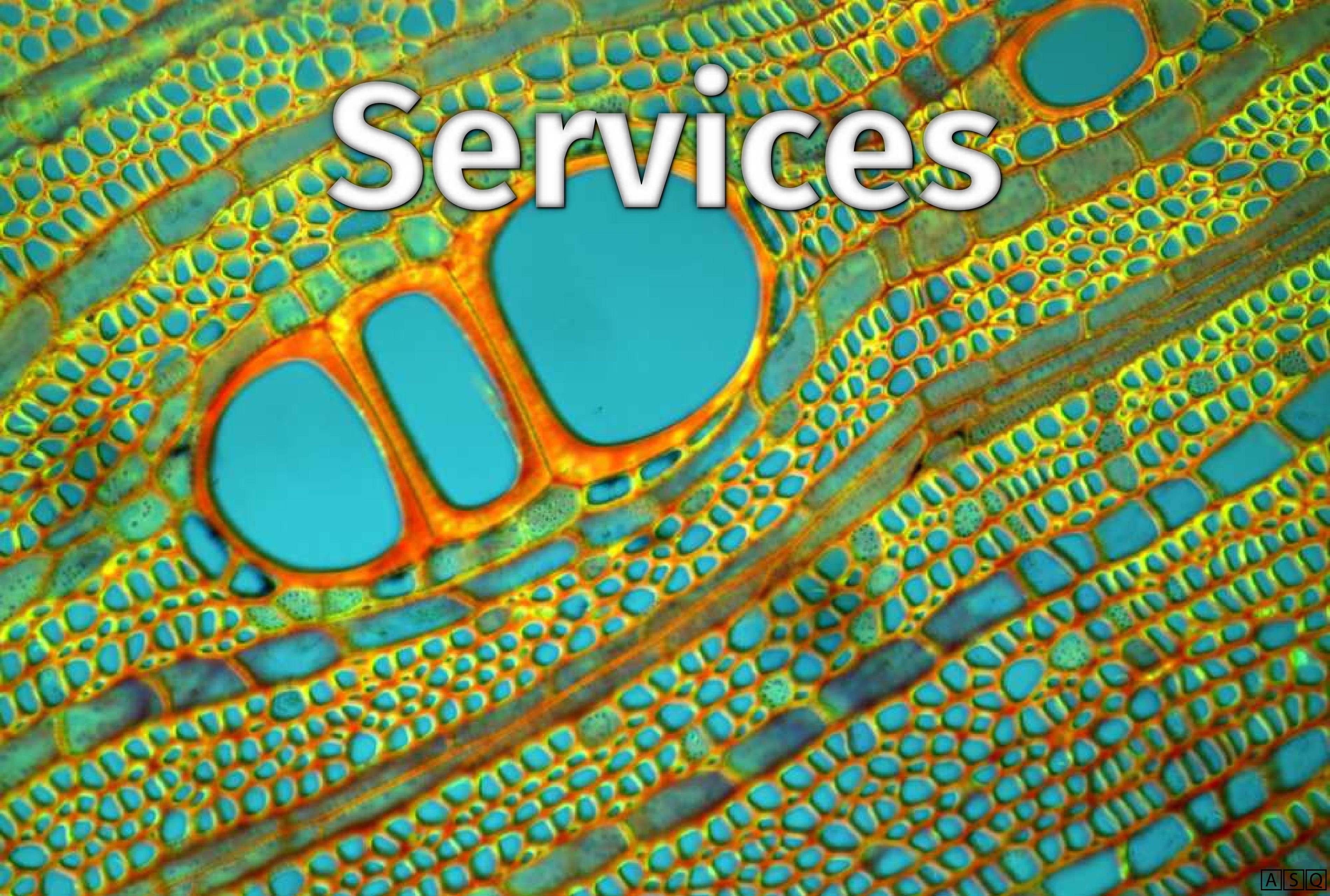


CLOUD CAM

now

Front Yard is offline. It might be because of an electrical outage, someone unplugging the camera or a bad Internet connection.

Every Thing as a Service

A high-magnification microscopic image of plant tissue, likely a stem or root cross-section. The image shows several large, circular tracheids with prominent orange-red borders, which are part of the vascular system. The surrounding tissue consists of smaller, polygonal cells with yellowish-green borders. The overall color palette is dominated by shades of blue, green, and orange.

Services



Services Interoperability



A microscopic image of plant tissue, likely a leaf cross-section, showing various types of cells. Large, central, polygonal cells with thick blue walls are visible, surrounded by smaller, more numerous green and yellowish cells. The overall pattern is organized into distinct layers and structures.

Services
Interoperability
Availability



Services
Interoperability
Availability
Composition

Microservices



Microservices Continuous Change



Microservices

Continuous Change

Small Size or Low Coupling?

Microservices

Continuous Change

Small Size or Low Coupling?

Recomposition

API-Evolution



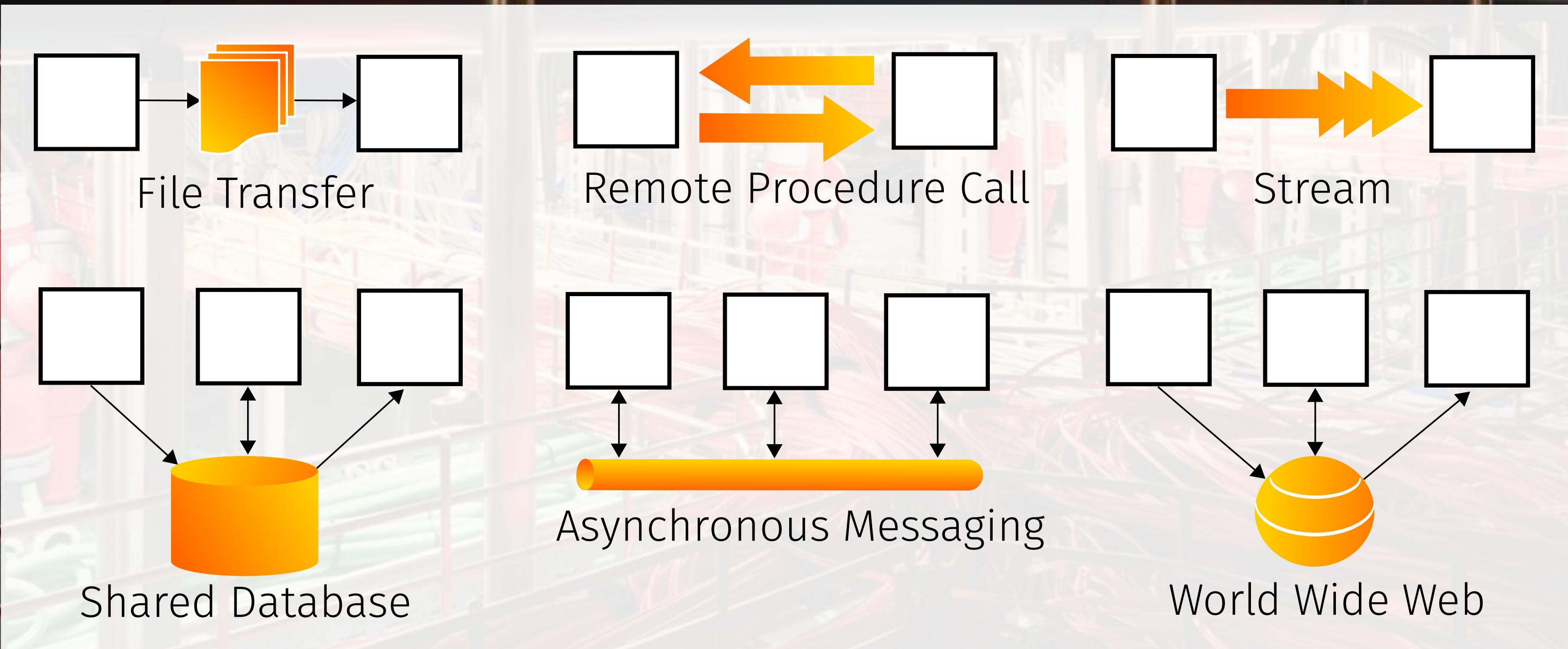


There's an app adapter for that



API Connectors

API Connectors



API Strategy

API Strategy

Open or Closed?

API Strategy

Open or Closed?

Some services are more equal than others

Some services are more equal than others

(The year we lost net neutrality)

Web Evolution

Re-decentralized

<https://scholar.social/@pautasso>
[dat://...](dat:///...)
[ipfs://...](ipfs:///...)

Centralized

<https://www.twitter.com/pautasso>

Decentralized

<http://www.pautasso.info/rss.xml>

The background of the image is a clear blue sky with scattered white clouds. The clouds are wispy and vary in size, creating a sense of depth. The overall atmosphere is bright and airy.

cloud



cloud

Fog



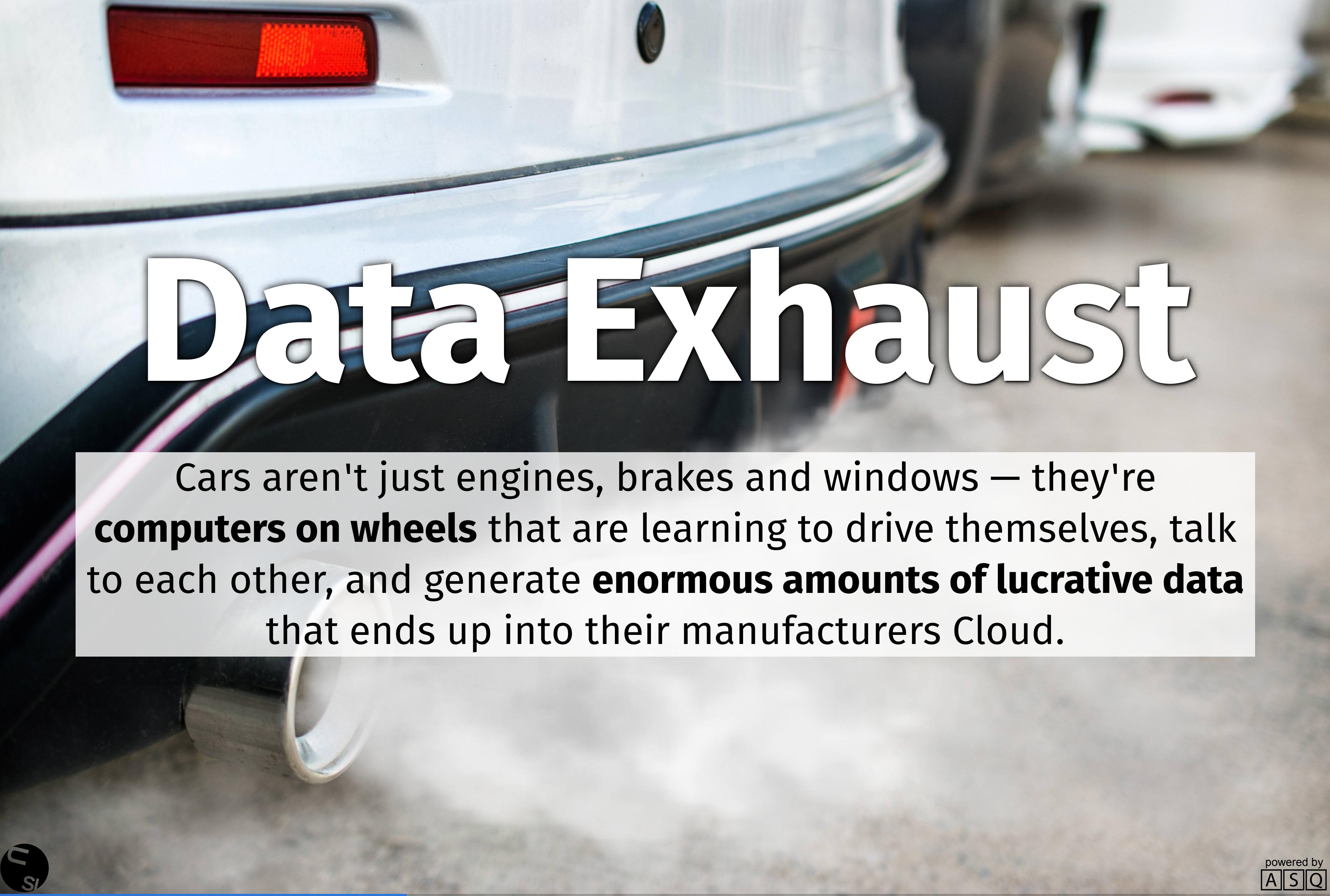
cloud

Edge

Fog

A close-up photograph of a car's exhaust pipe. The pipe is dark and cylindrical, with a bright red glow at the very tip where it meets the ground, suggesting the car is still running or has just been driven. A plume of white smoke or steam is visible at the end of the pipe. The background is blurred, showing the side of the car and some other vehicles.

Data Exhaust



Data Exhaust

Cars aren't just engines, brakes and windows – they're **computers on wheels** that are learning to drive themselves, talk to each other, and generate **enormous amounts of lucrative data** that ends up into their manufacturers Cloud.

Some devices are more equal than others

Some devices are more equal than others

(The year we lost control
over "our own" devices)



One Computer
Many Users

One Computer
One User





Many
Computers
One User

How many Web-enabled devices do you have?



0

1

2

3

4

>4

0

0

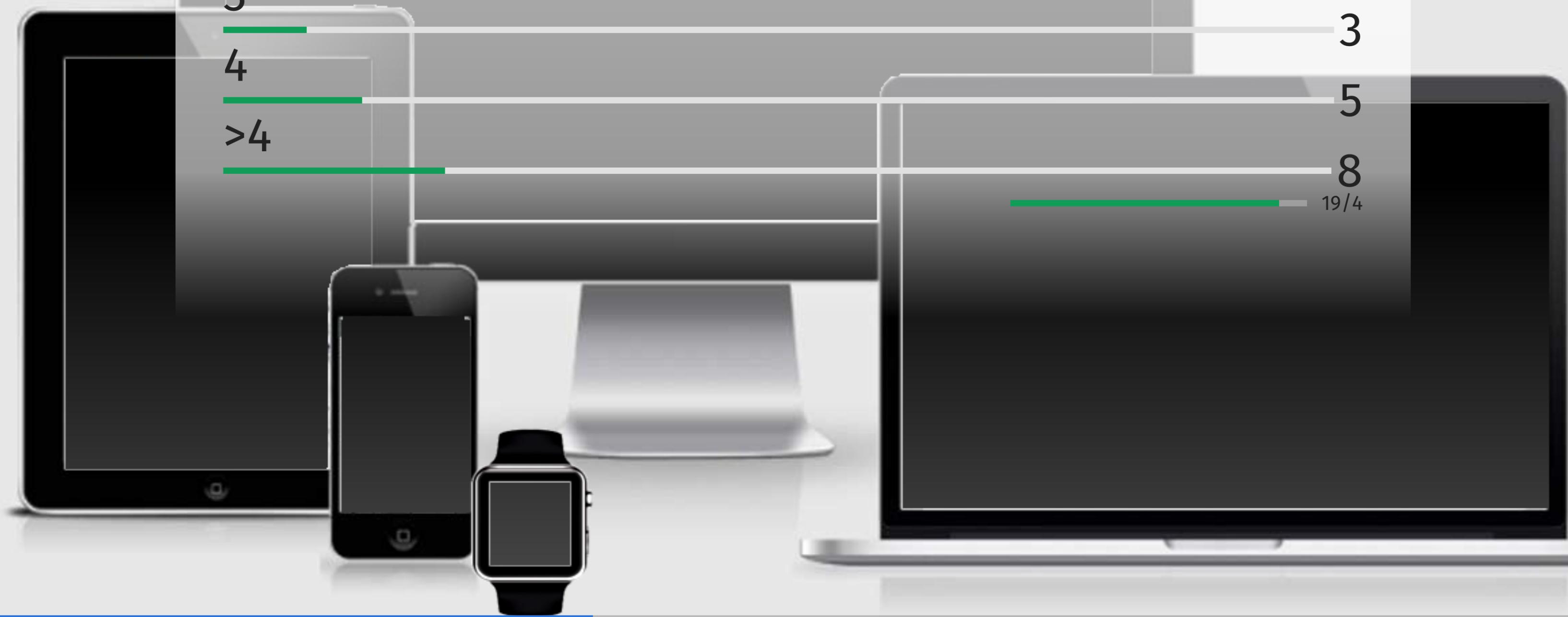
2

3

5

8

19/4



Which Web-enabled devices do you have?



Desktop PC

9

Laptop

20

Netbook

0

Tablet

11

Smart Phone

18

Watch

5

Glasses

0

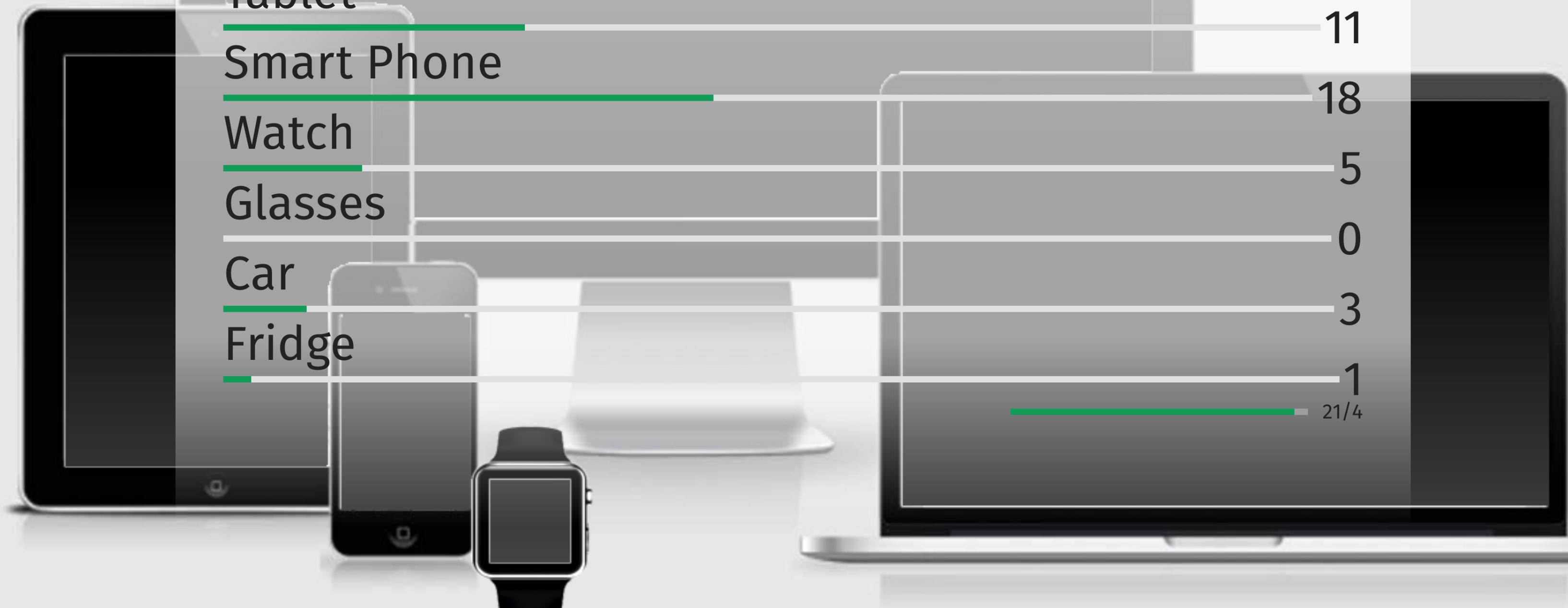
Car

3

Fridge

1

21/4



Apple continuity



Samsung Flow



What about the Web?

Responsive



Liquid

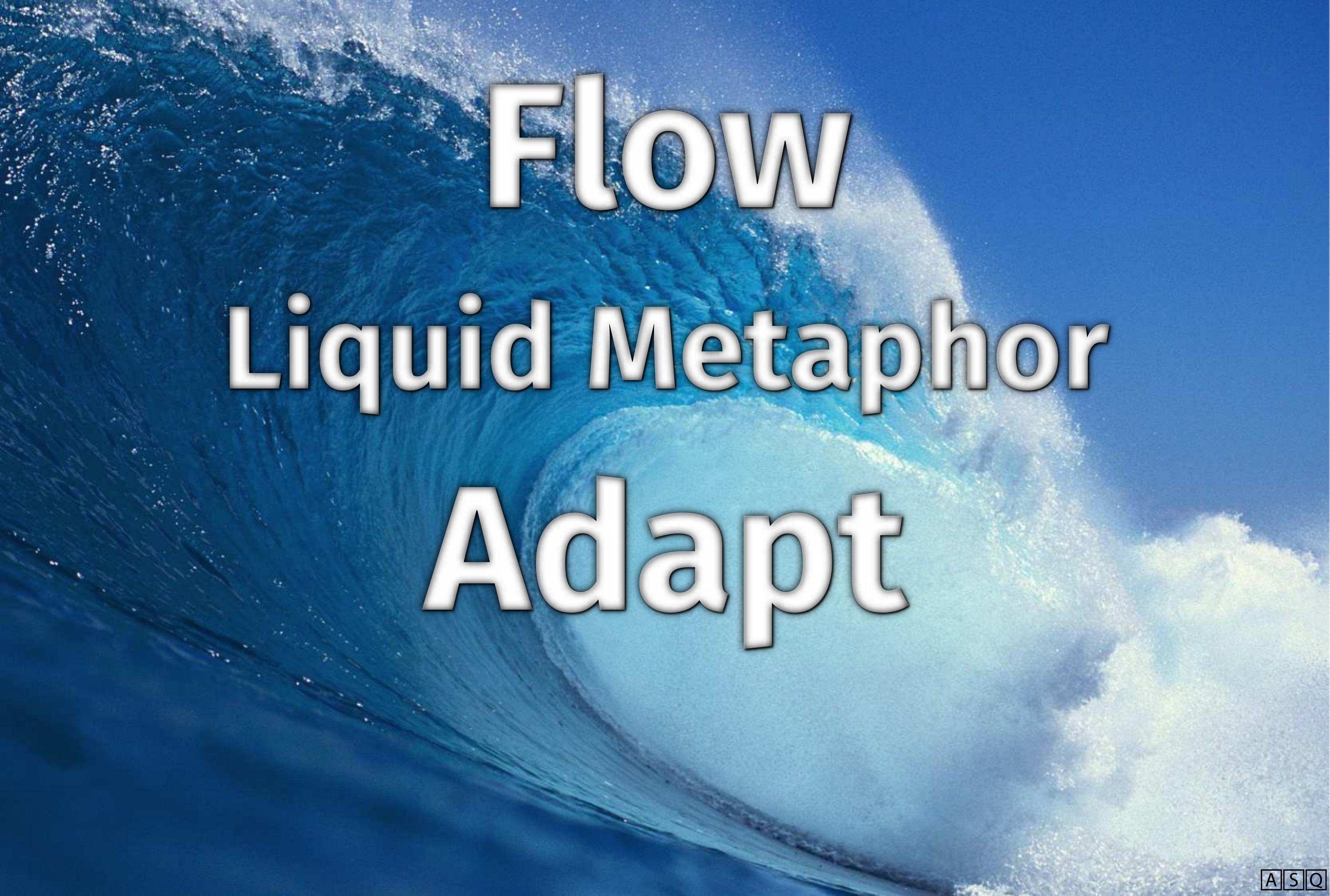


Liquid Metaphor



Flow

Liquid Metaphor



Flow
Liquid Metaphor
Adapt

Liquid Software

1. **Adapt** the distributed user interface to fully take advantage of the **set of** devices

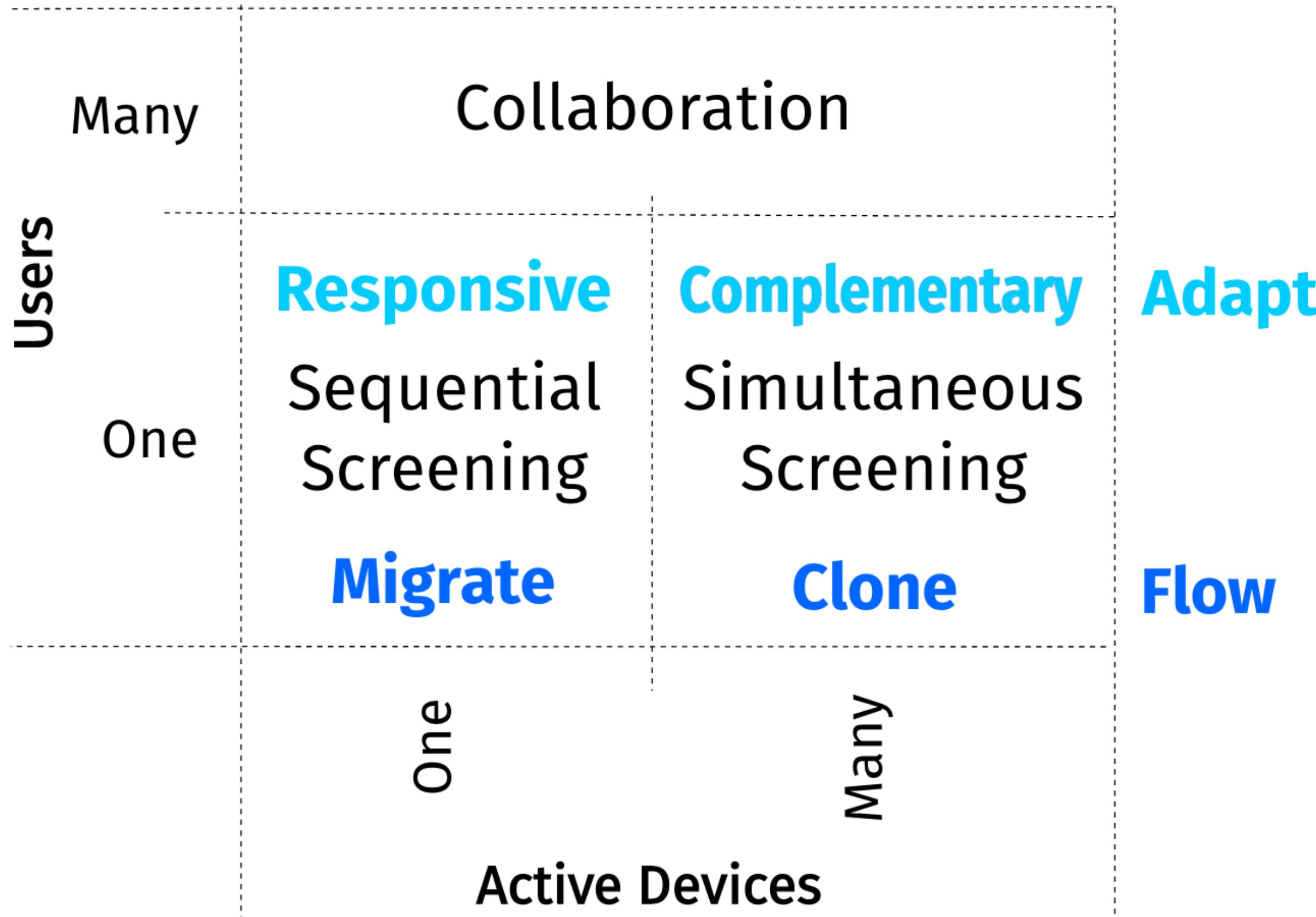
Liquid Software

1. **Adapt** the distributed user interface to fully take advantage of the **set of** devices
2. Seamlessly migrate and clone **running** applications across devices

Liquid Software

1. **Adapt** the distributed user interface to fully take advantage of the **set of** devices
2. Seamlessly migrate and clone **running** applications across devices
3. Does not **leak** into untrusted devices

Liquid User Experience



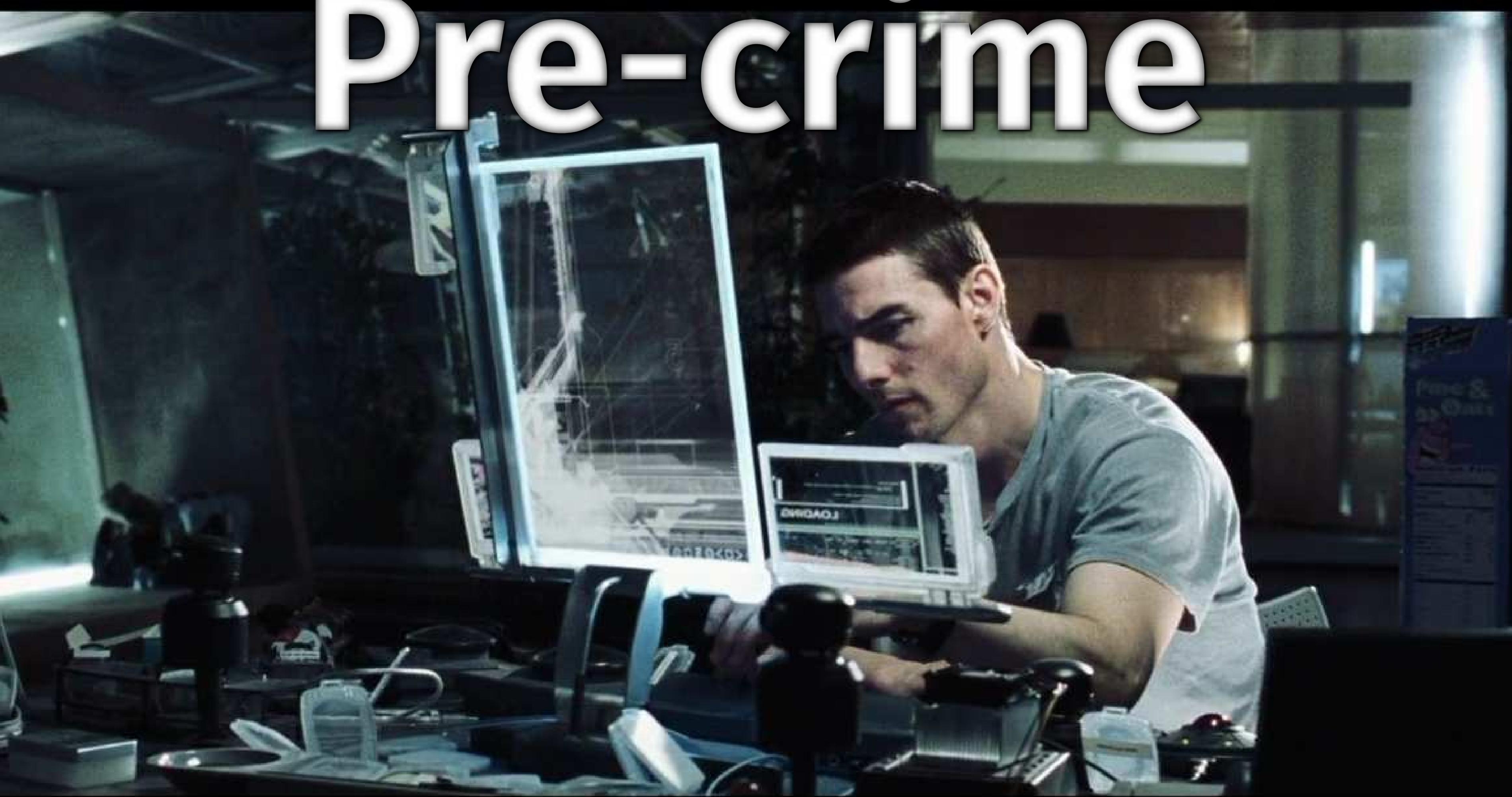
A collage of various scenes illustrating multitasking and digital communication. It includes a woman in a car looking at her phone, a man sitting on a couch holding a smartphone, a person working at a desk with multiple monitors, a person working at a counter with a laptop, and a person sitting at a table with a laptop. The overall theme is the integration of physical and digital spaces.

Second Screen

collaboration



Pre-crime



education



Flow

How to seamlessly flow running applications across devices?

1. Migrate = Copy + Delete
2. Copy
3. Clone = Copy + Synchronize

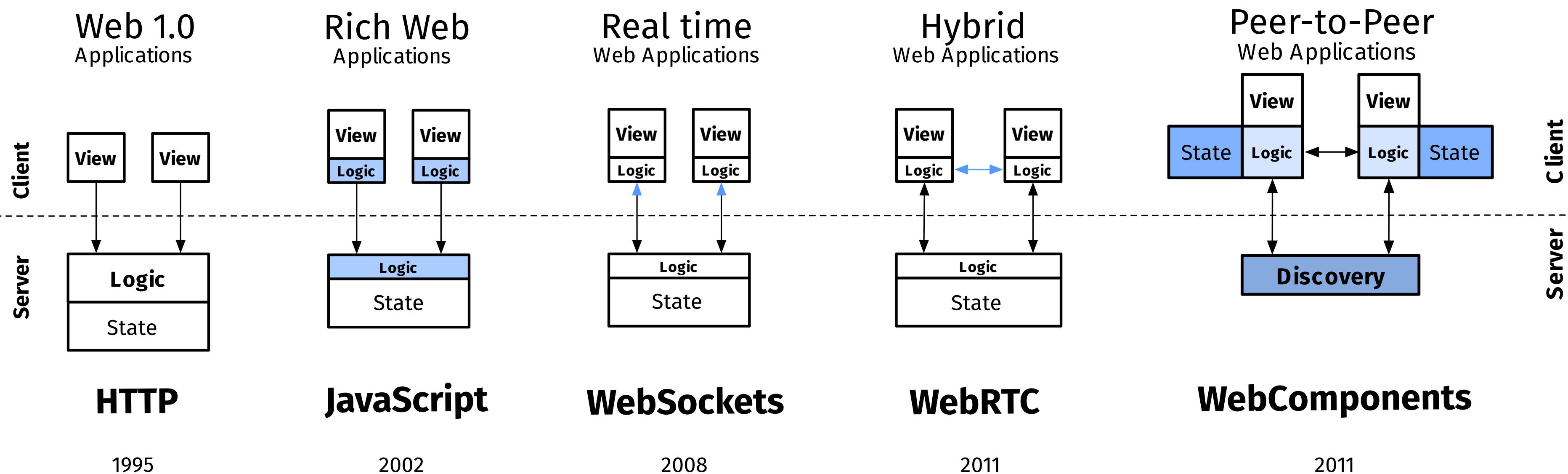
Adapt

How to take advantage of different devices?

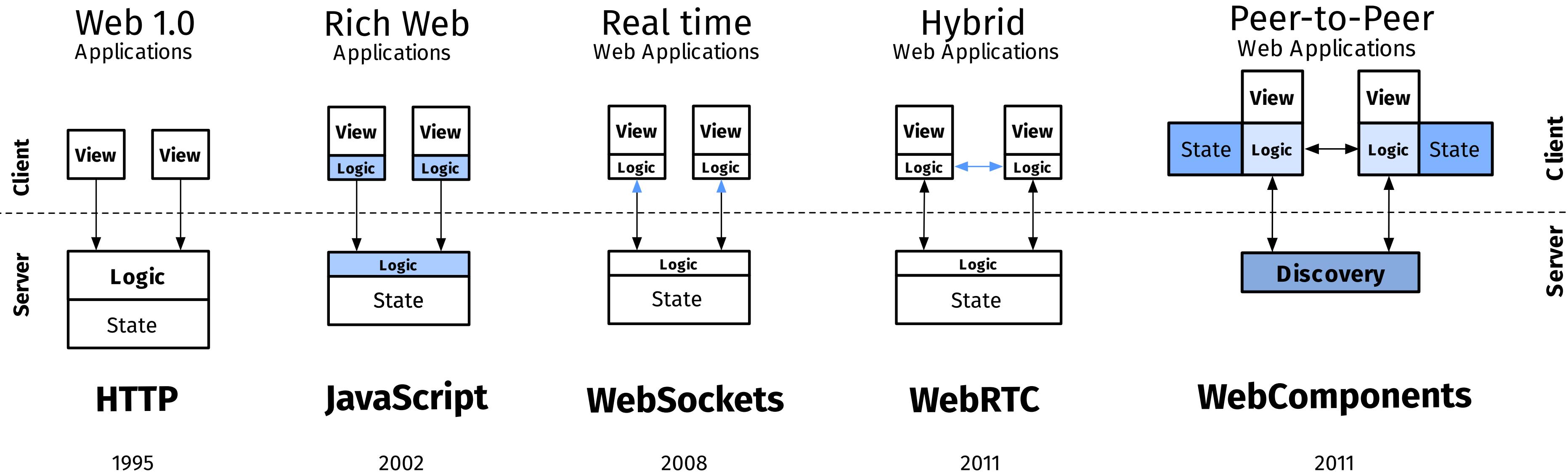
1. Manual
2. Automatic: Responsive (one device)
3. Automatic: Complementary (many devices)

How Liquid is the Web?

Web Architecture History



Liquid Web Applications

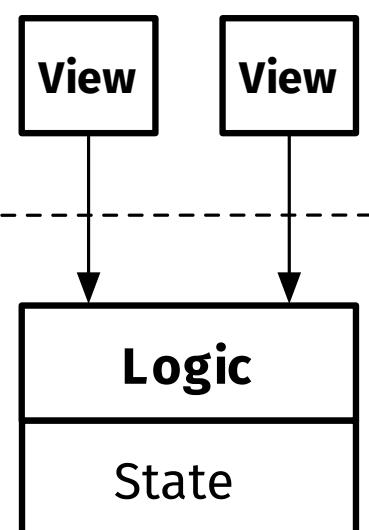


Liquid Web Applications

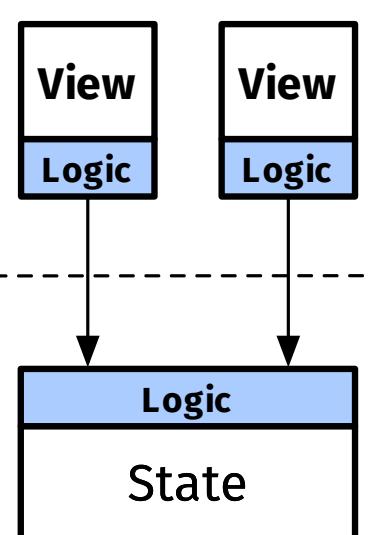
Migrate/Copy

Clone (Synchronization)

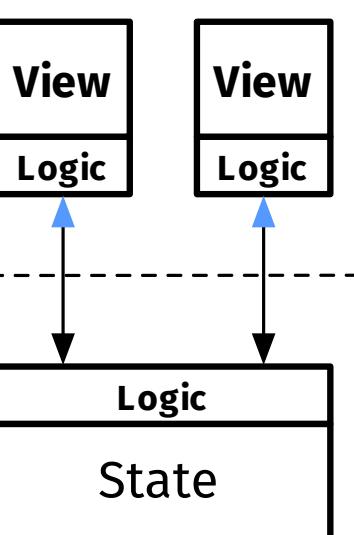
Web 1.0
Applications



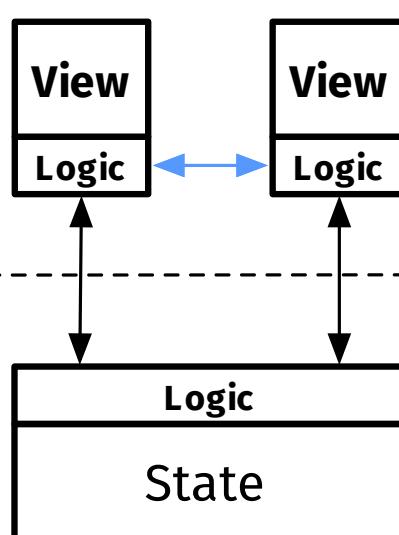
Rich Web
Applications



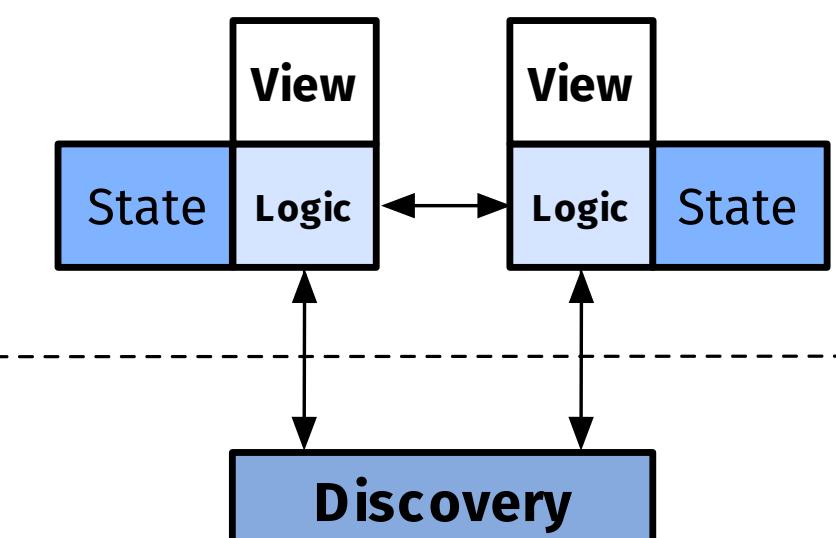
Real time
Web Applications



Hybrid
Web Applications



Peer-to-Peer
Web Applications



HTTP

1995

JavaScript

2002

WebSockets

2008

WebRTC

2011

WebComponents

2011

State Synchronization

When to share updates?

1. Batch (Copy)
2. Trickle (Synchronize)

State Identification

What needs to be migrated/synchronized?

1. Explicit
2. Implicit

Granularity

What needs to be migrated/synchronized?

1. OS/VM (Implicit)
2. Application (Implicit)
3. Component (Explicit)

Deployment

When to install the app?

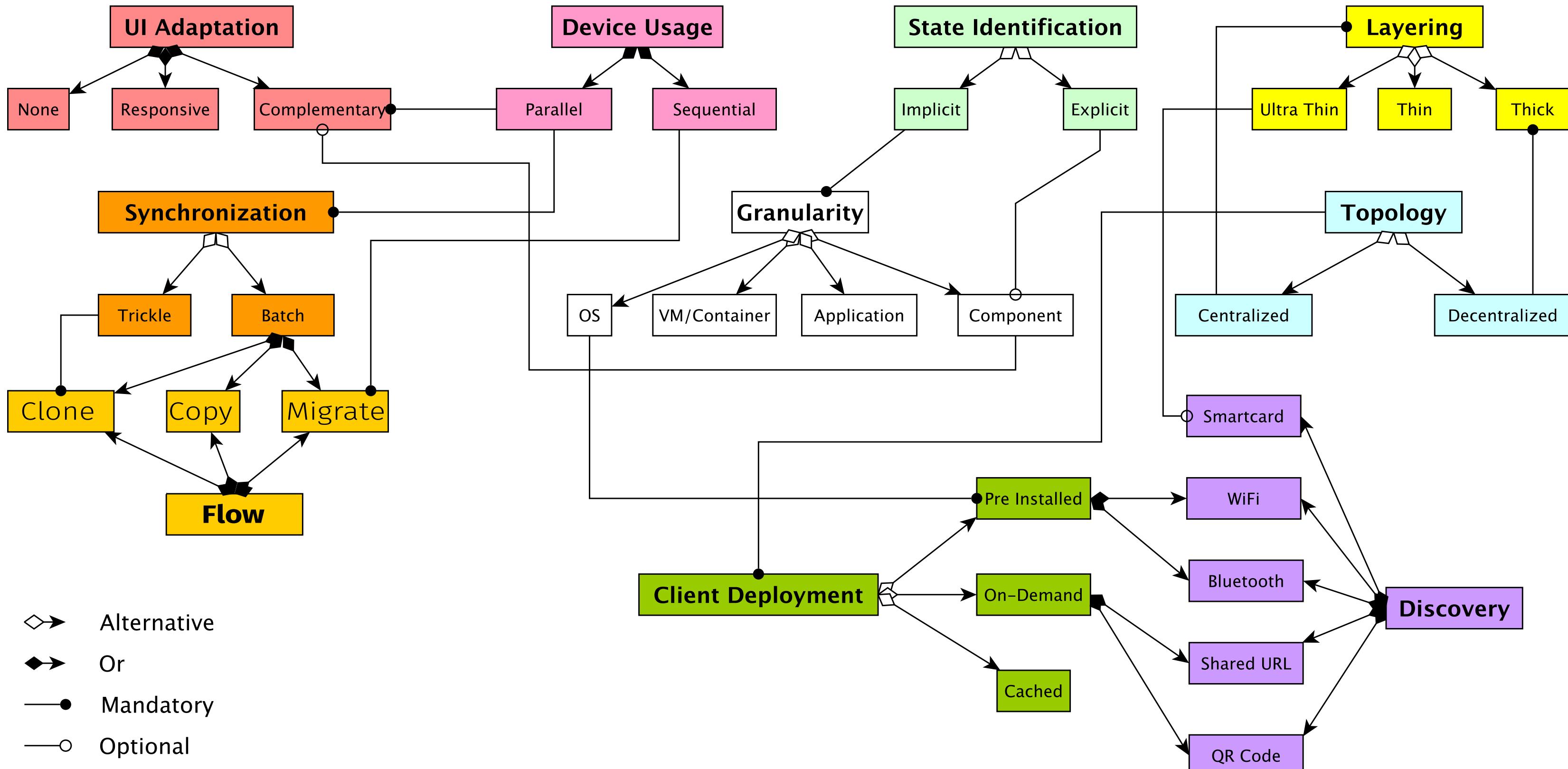
1. Pre-installed
2. On-Demand

Discovery

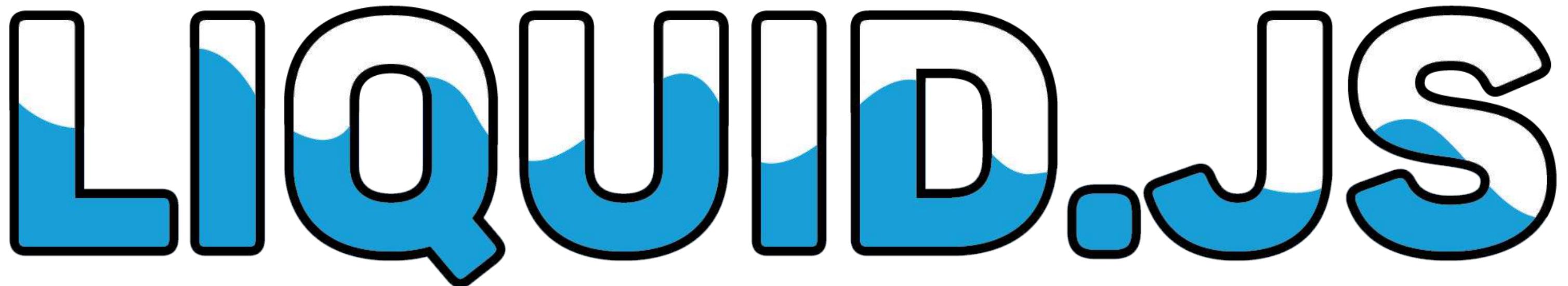
How to establish trust between paired devices?

1. Smartcard
2. WiFi
3. Bluetooth
4. Shared URL
5. QR Code

Liquid Software Design Space



How to build liquid web apps?



Demo <http://liquid.inf.usi.ch>

- Liquid Web Components
- Liquid Storage (Peer-to-Peer State Synchronization)
- Liquid User Experience API
- Liquid Web Workers (Peer-to-Peer Offloading)

3 States of Software

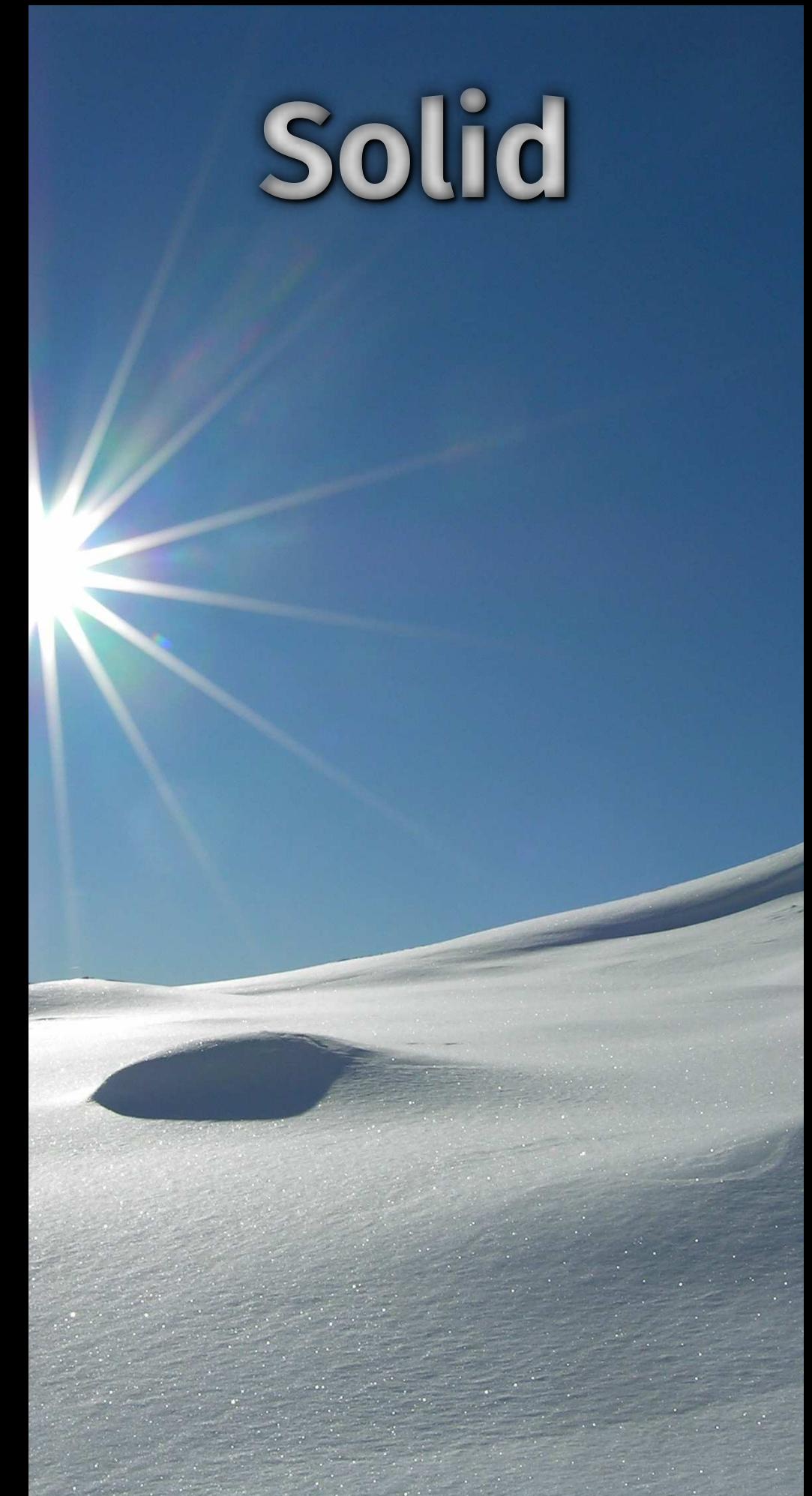
Cloud



Liquid



Solid



A Brief History Of Liquid Software

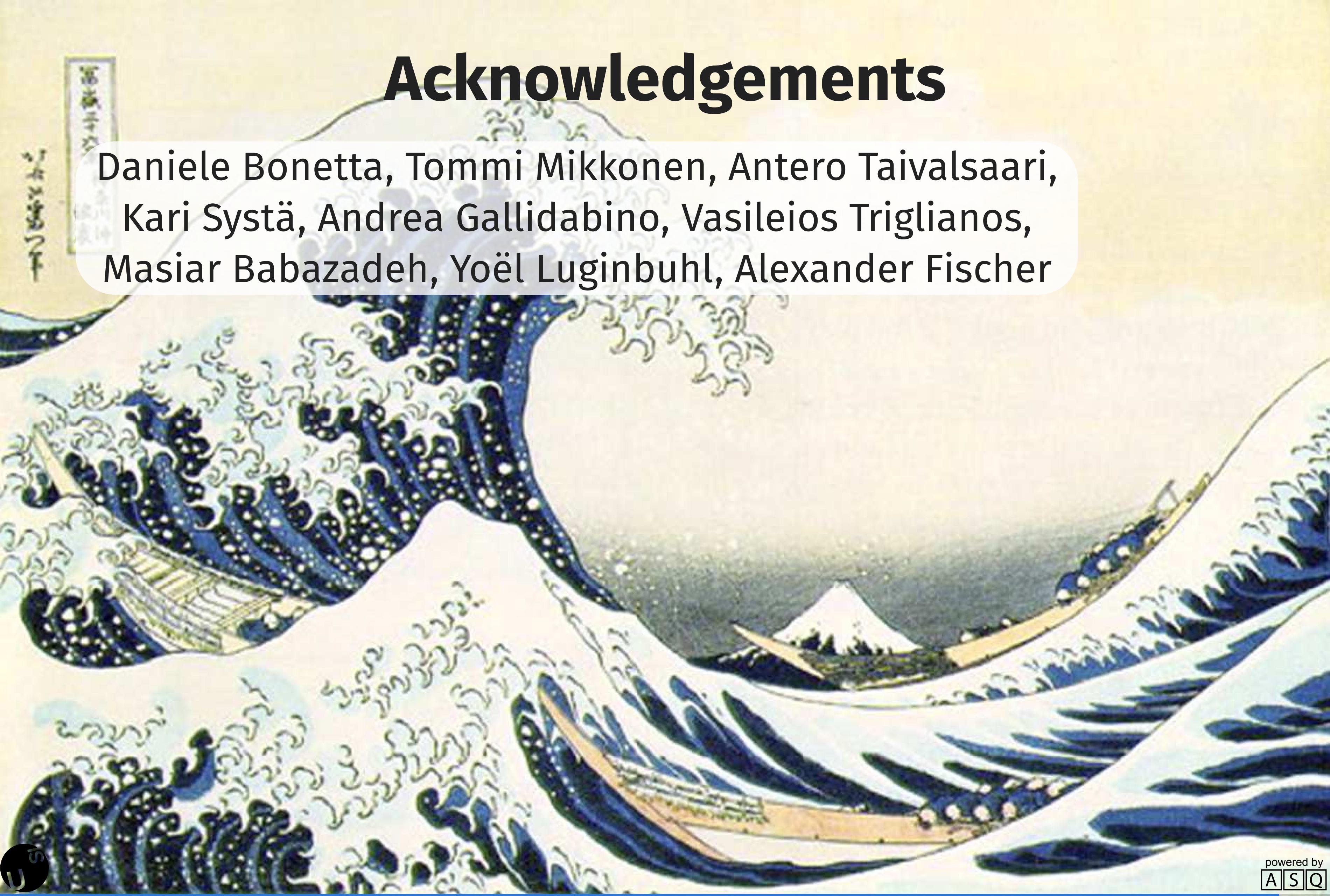
- 1996 Liquid Information Environment (Frode Hegland)
- 1998 Liquid Software (U. Arizona and Princeton U.)
- 2003 Fluid Computing (IBM Zurich Research Lab)
- 2005 Think Liquid (BEA SOA Middleware Marketing)
- 2008 Liquid Publications (U. Trento et al.)
- 2011 Liquid Web Services (USI Lugano)
- 2013 Liquid Web Streams (USI Lugano)
- 2014 Liquid Software Manifesto (TU. Tampere)
- 2015 Liquid Web Apps (USI Lugano & TU Tampere)

Conclusions

- Software Architectures periodically swing between:
 - Open ↔ Closed
 - Centralized ↔ Decentralized
 - Static ↔ Dynamic
 - Simple ↔ Complex
- Liquid Software flows and adapts across your trusted devices
- Liquid.js for Polymer: migrate and clone stateful Web components and peer-to-peer offloading of Web workers across multiple devices

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Masiar Babazadeh, Yoël Luginbuhl, Alexander Fischer



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- Andrea Gallidabino, and Cesare Pautasso, [The Liquid.js Framework for Migrating and Cloning Stateful Web Components across Multiple Devices](#), Proc. of the 25th International World Wide Web conference, Montreal, Canada, ACM, pp. 183-186, April, 2016.
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- Daniele Bonetta, and Cesare Pautasso, [An Architectural Style for Liquid Web Services](#), 9th Working IEEE/IFIP Conference on Software Architecture (WICSA 2011), Boulder, CO, USA, pp. 232-241, June, 2011.