DEPLOYING STATEFUL WEB COMPONENTS ON MULTIPLE DEVICES WITH LIQUID.JS FOR POLYMER

Andrea Gallidabino
Cesare Pautasso
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

# Devices

# Users

# Devices

# Users
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
SEQUENTIAL SCREENING
SEQUENTIAL SCREENING
SEQUENTIAL SCREENING
SEQUENTIAL SCREENING
SEQUENTIAL SCREENING
SEQUENTIAL SCREENING
SIMULTANEOUS SCREENING
SIMULTANEOUS SCREENING
SIMULTANEOUS SCREENING
SIMULTANEOUS SCREENING
SIMULTANEOUS SCREENING
SIMULTANEOUS SCREENING
COLLABORATIVE SCENARIO
COLLABORATIVE SCENARIO

Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
COLLABORATIVE SCENARIO
COLLABORATIVE SCENARIO
COLLABORATIVE SCENARIO
COLLABORATIVE SCENARIO
MULTI-DEVICE SOFTWARE

Adapts to a set of heterogeneous devices

Dynamic Migration (sequential scenarios)

State Synchronisation (collaborative scenarios)
METAPHOR
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

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METAPHOR

[Image of a water tap and a globe with the letter 'W', a cup, and a device with the letter 'L' on it]
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

METAPHOR
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

METAPHOR

[Images of a water tap, internet globe, a cup, and a computer display]
LIQUID APPLICATIONS
LIQUID APPLICATIONS

Roaming from a device to another one
LIQUID APPLICATIONS

Roaming from a device to another one following user attention
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

LIQUID.JS FOR POLYMER
COMPONENT-BASED
COMPONENT-BASED
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT-BASED

UI
LOGIC
DATA

UI
LOGIC
DATA
COMPONENT-BASED

WebComponents Standard
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT-BASED

WebComponents Standard

Polymer Framework
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT-BASED

WebComponents Standard
Polymer Framework
Fine-grained decomposition
COMPONENT API

Device 1

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1
Create(component_Type, device)

Device 2
COMPONENT API

Device 1

Create(component_Type, device)

Delete(component)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)

Delete(component)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)

Device 2
COMPONENT API

Device 1

Create(component_Type, device)

Delete(component)

Move(component, device)

Device 2
SEQUENTIAL SCREENING
COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1
Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)

Device 2
COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)
Pair(component_1, component_2)

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)
Pair(component_1, component_2)

SYNC

Device 2
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)
Pair(component_1, component_2)
Clone(component, device)

Device 2

SYNC
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Device 2

Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)
Pair(component_1, component_2)
Clone(component, device)
Unpair(component_1, component_2)

SYNC
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT API

Device 1

Create(component_Type, device)
Delete(component)
Move(component, device)
Fork(component, device)
Pair(component_1, component_2)
Clone(component, device)
Unpair(component_1, component_2)

Device 2
SIMULTANEOUS SCREENING
COLLABORATIVE SCENARIO
STATEFUL COMPONENTS
STATEFUL COMPONENTS
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

STATEFUL COMPONENTS
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
VARIABLE API
VARIABLE API

Component

Var 1  Var 2  Var 3
VARIABLE API
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

VARIABLE API

Liquid Component

Liquid Behavior

Var 1  Var 2  Var 3
VARIABLE API

Liquid Component

Liquid Behavior

Var 1  Var 2  Var 3

Register (variable)
VARIABLE API

Liquid Component

Liquid Behavior

Register (variable)
VARIABLE API

Liquid Component

Register (variable)

Pair (var_1, var_2)
VARIABLE API

Liquid Component

Register (variable)

Pair (var_1, var_2)
VARIABLE API

Liquid Component

Liquid Behavior
Var 1
Var 2
Var 3

Register (variable)
Pair (var_1, var_2)

Liquid Component

Liquid Behavior
Var 4
Var 5

SYNC
VARIABLE POLICIES
VARIABLE POLICIES

Sharing
VARIABLE POLICIES

Sharing

Component Scope
VARIABLE POLICIES

Sharing

Component Scope

Device Deployment
VARIABLE POLICIES

Sharing

Component Scope

Device Deployment

Persistence
SHARING POLICY
SHARING POLICY

Liquid Component

1  2  3

Liquid Component

1  2  3
SHARING POLICY

Liquid Component

1
2
3

Cloned

Liquid Component

1
2
3

Liquid Component

1
2
3
SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared 1 2 3

Liquid Component
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

SHARING POLICY

Liquid Component

1

2

3

Cloned Liquid Component

1

2

3

Shared 1 2 3

Liquid Component

1

2

3
SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared Local

Liquid Component

1 2 3

1 2 3
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared 1 3
Local 2

Liquid Component
SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared 1 3

Local 2
SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared
Local
Global
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared 1
Local 2
Global 3
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

SHARING POLICY

Liquid Component

Cloned Liquid Component

Shared 1
Local 2
Global 3
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPONENT SCOPE
COMPONENT SCOPE
COMPONENT SCOPE

Liquid Component 1
1
2
3

Liquid Component 1
1
2
3

Liquid Component 2
4
5

Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
COMPONENT SCOPE

Liquid Component 1

1
2
3

Liquid Component 2

4
5

Intra-component

Liquid Component 1

1
2
3

5

COMPONENT SCOPE

Liquid Component 1

1

2

3

Liquid Component 2

4

5

Intra-component
COMPONENT SCOPE

Liquid Component 1

1 2 3

Liquid Component 2

4 5

Intra-component

Liquid Component 1

1 2 3

1 2 3

Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
COMPONENT SCOPE

Liquid Component 1

1
2
3

Intra-component

Inter-component

Liquid Component 1

1
2

Liquid Component 2

4
5

Intra-component

Inter-component
COMPONENT SCOPE

Intra-component

Inter-component
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

DEVICE DEPLOYMENT
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

DEVICE DEPLOYMENT

LC1

1

LC2

2

LC3

3

4

5
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

DEVICE DEPLOYMENT

LC1

1

LC2

2

LC3

3

4

5

One device
DEVICE DEPLOYMENT

One device
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

DEVICE DEPLOYMENT

One device
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

DEVICE DEPLOYMENT

One device

Many devices
DEVICE DEPLOYMENT

One device

Many devices
PERSISTENCE POLICY
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Default’
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Default’

Volatile
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Changed’

Volatile
PERSISTENCE POLICY

Volatile
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Default’

Volatile
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Default’

Volatile
Session
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Changed’

Volatile
Session
PERSISTENCE POLICY

Volatile

Session
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Changed’

Volatile
Session
PERSISTENCE POLICY

Volatile
Session
PERSISTENCE POLICY

Variable Value ‘Default’

Volatile Session
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Default’

Volatile
Session
Persistent
PERSISTENCE POLICY

- Volatile
- Session
- Persistent

Liquid Component

Variable
Value ‘Changed’
PERSISTENCE POLICY

- Volatile
- Session
- Persistent
PERSISTENCE POLICY

Liquid Component

Variable
Value ‘Changed’

Volatile
Session
Persistent
## DECISION

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<th>Liquid Software</th>
<th>Liquid.js Framework</th>
<th>Components</th>
<th>Variables</th>
<th>Storage</th>
<th>Conclusions</th>
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Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer
**DECISION**

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<th>Scope</th>
<th>Deployment</th>
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<td>Persistence</td>
<td></td>
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<tr>
<td>Sharing</td>
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## DECISION

<table>
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<tr>
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<th>Intra-Component</th>
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<tr>
<td></td>
<td>1 Device</td>
<td>Many</td>
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<td>Persistent</td>
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### Persistent
- **Global**
  - Session: Session Storage
  - Volatile: Browser Memory
- **Shared**
  - Session: Session Storage
  - Volatile: Browser Memory
- **Local**
  - Session: Session Storage

### Session
- **Global**
  - Intra: Server
  - Inter: Session Storage
- **Shared**
  - Intra: Server
  - Inter: Session Storage
- **Local**
  - Intra: Session Storage

### Volatile
- **Shared**
  - Intra: Browser Memory
  - Inter: Browser Memory
- **Local**
  - Intra: Browser Memory
  - Inter: Browser Memory

### Sharing
- Global
- Shared
- Local

### Storage
- Server
- Session Storage
- Browser Memory

---

**Context**
- Liquid Software
- Liquid.js Framework
- Components
- Variables

**Conclusions**
## DECISION

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<td>Browser Memory</td>
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### Scope
- **Persistent**
- **Session**
- **Volatile**

### Storage
- **Local Storage**
- **Session Storage**
- **Browser Memory**
- **Server**
- **Global**
- **Shared**
- **Local**

### Deployment
- **I Device**
- **Many**
WHERE DO WE STORE THE STATE
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1 2 3

Liquid Behavior

Device 2

Liquid Component

1 2 3

Liquid Behavior
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1
2
3

Liquid Behavior

WebRTC

Device 2

Liquid Component

1
2
3

Liquid Behavior

Device 1

Device 2
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1 2 3

Liquid Behavior

Device 2

Liquid Component

1 2 3

Liquid Behavior

Server

WebRTC
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1 2 3

Liquid Behavior

Device 2

Server

WebSocket

WebRTC

Liquid Component

1 2 3

Liquid Behavior

Device 2

Server

WebSocket

WebRTC

Liquid Component

1 2 3

Liquid Behavior
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

Liquid Behavior

Device 2

Liquid Component

Liquid Behavior

Server

WebSockets

WebRTC
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1

2

3

Liquid Behavior

Server

Database

WebSockets

WebRTC

Device 2

Liquid Component

1

2

3

Liquid Behavior

WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1

2

3

Liquid Behavior

Server

Database

WebSockets

WebRTC

Device 2

Liquid Component

1

2

3

Liquid Behavior
WHERE DO WE STORE THE STATE

Device 1
Liquid Component

1
2
3

Liquid Behavior

Server
Database

Device 2
Liquid Component

1
2
3

Liquid Behavior

WebSockets
WebRTC

WHERE DO WE STORE THE STATE

Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

WHERE DO WE STORE THE STATE
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1  2  3

Liquid Behavior
Browser Memory

Server

Database

WebSockets

WebRTC

Device 2

Liquid Component

1  2  3

Liquid Behavior
Browser Memory
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1

Liquid Behavior

Browser Memory

2

3

Server

Database

WebSockets

WebRTC

Device 2

Liquid Component

1

Liquid Behavior

Browser Memory

2

3

4

3

4

Conclusions
WHERE DO WE STORE THE STATE

Device 1

Liquid Component

1

Liquid Behavior

2

Browser Memory

3

Local Storage

4

Device 2

Liquid Component

1

Liquid Behavior

2

Browser Memory

3

Local Storage

4

Server

Database

WebSocket

WebRTC

Connects

Context

Liquid Software

Liquid.js Framework

Components

Variables

Storage

Conclusions
WHERE DO WE STORE THE STATE

Device 1
- Liquid Component
- Liquid Behavior
- Browser Memory
- Local Storage
- Session Storage

Server
- Database
- WebSockets
  - WebRTC

Device 2
- Liquid Component
- Liquid Behavior
- Browser Memory
- Local Storage
- Session Storage

WHERE DO WE STORE THE STATE

Device 1
- Liquid Component
- Liquid Behavior
- Browser Memory
- Local Storage
- Session Storage

Server
- Database
- WebSockets
  - WebRTC

Device 2
- Liquid Component
- Liquid Behavior
- Browser Memory
- Local Storage
- Session Storage

WHERE DO WE STORE THE STATE
CONCLUSION
CONCLUSION

Solution for the three use case scenarios:
CONCLUSION

Solution for the three use case scenarios:

sequential screening, simultaneous screening, collaborative
CONCLUSION

Solution for the three use case scenarios:

- sequential screening
- simultaneous screening
- collaborative

Transparently synchronise component state
CONCLUSION

Solution for the three use case scenarios:

- sequential screening
- simultaneous screening
- collaborative

Transparently synchronise component state

Decentralised environment
FUTURE WORK

UI

LOGIC

DATA
Deploying Stateful Web Components on Multiple Devices with Liquid.js for Polymer

COMPSAC‘14
A. Taivalsaari, T. Mikkonen, and K. Systä
Liquid Software Manifesto: The Era of Multiple Device Ownership and Its Implications for Software Architecture

ICWE’15
T. Mikkonen, K. Systä, and C. Pautasso
Towards liquid web applications

WICS’16
A. Gallidabino, C. Pautasso, T. Mikkonen, V. Ilvonen, K. Systä, J.-P. Voutilainen, and A. Taivalsaari.
On the architecture of liquid software: Technology alternatives and design space

WWW’16 (Demo paper)
A. Gallidabino, and C. Pautasso.
The Liquid.js framework for migrating and cloning stateful Web components across multiple devices