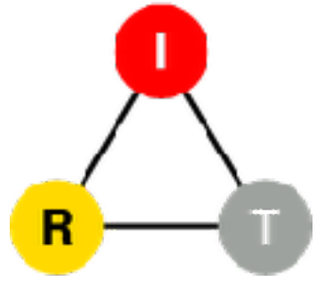

Prototyping Distributed IoT Applications with WebRTC

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Columbia University

SECE: Sense Everything, Control Everything

- Research Project
- Distributed end-to-end programmable IoT applications
- Deploy IoT applications to end-devices
- Application model: computation follows data
- Benefits: security & privacy, scalability, resiliency
- Challenges: heterogeneity, concurrency, hardware

SECE System Architecture

SECE App Repository

Deploy

AWS

SECE

SECE App Servers

Connect

Online Services

Connect

Private SECE App Server

SECE

User Interface

SECE

Personal Smart Object Cloud

Activity

SECE

SECE

Actuators

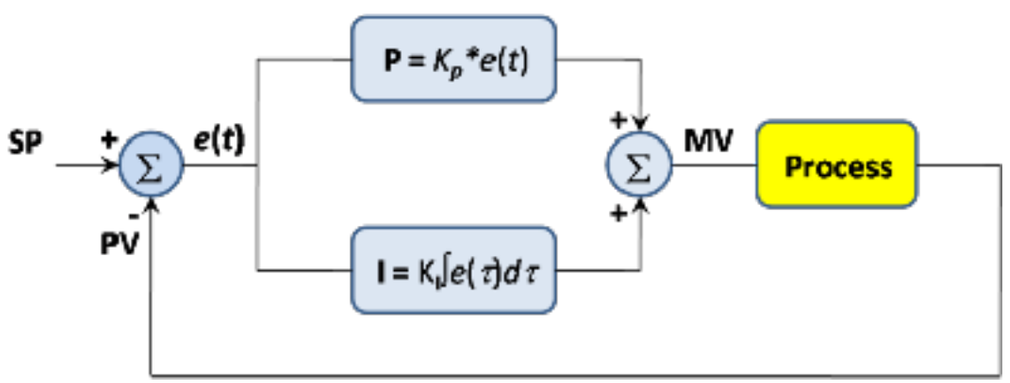
SECE

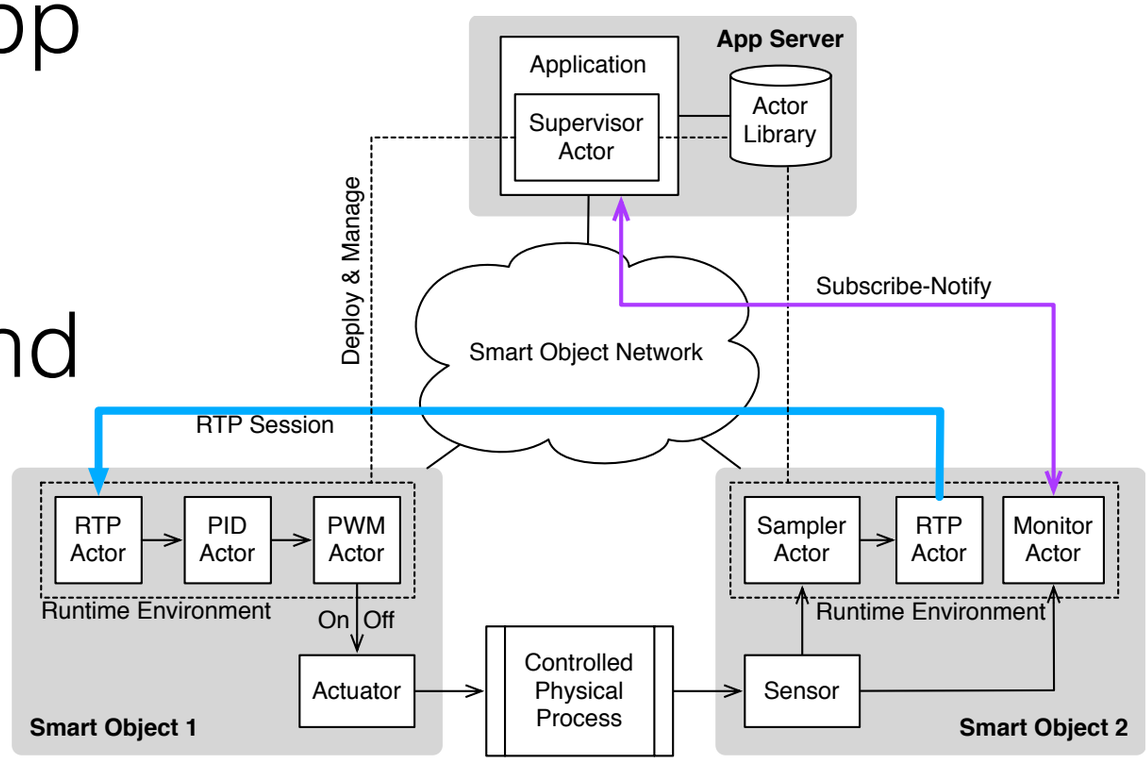
Sensors

Use Case: Internet PLC

Use of device programmability for control loops

1. PID controller implemented on a programmable IoT device.
2. In form of a JavaScript / Lua application installed by SECE.
3. SECE requests persistent app installation on IoT device.
4. App continuously adjusts actuator based on history and sensor data.
5. App keeps running until explicitly uninstalled.

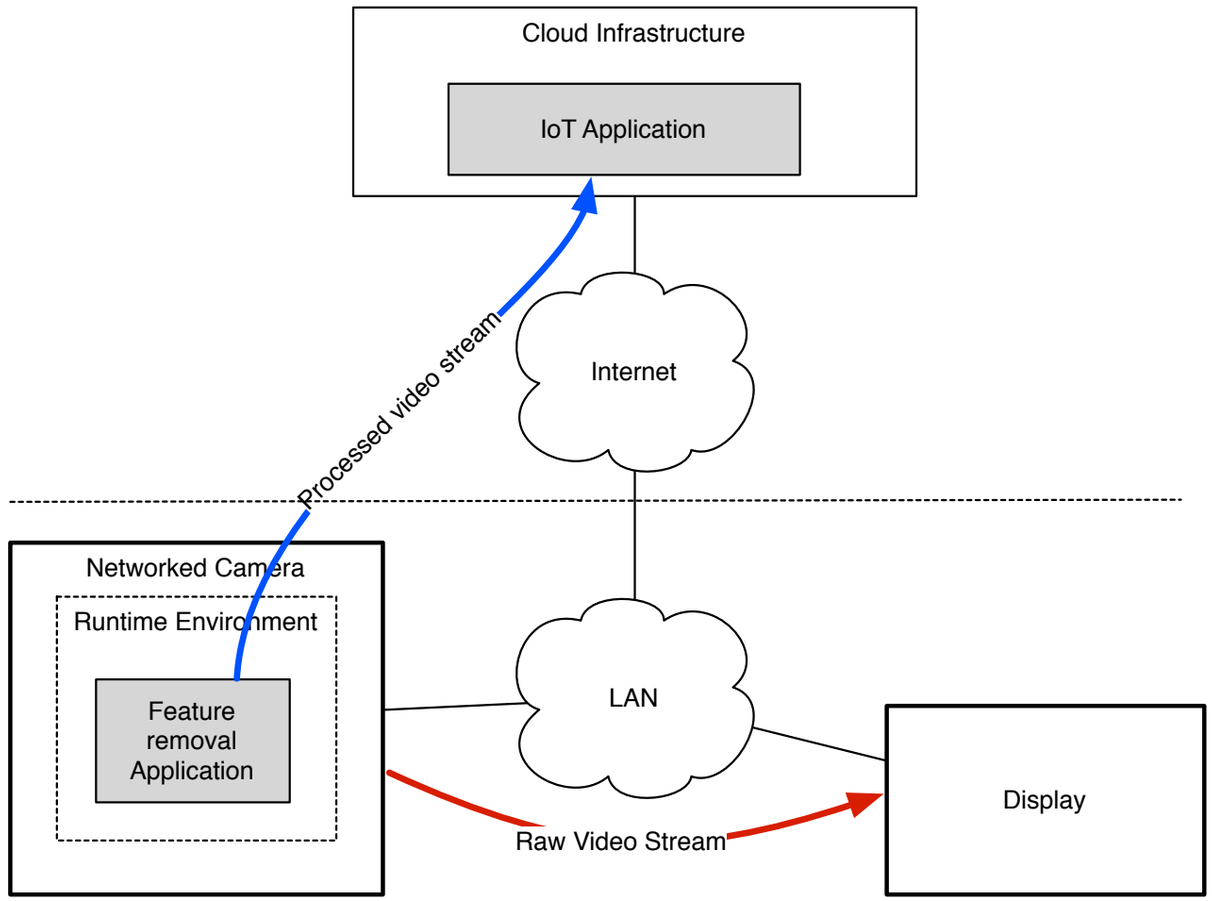




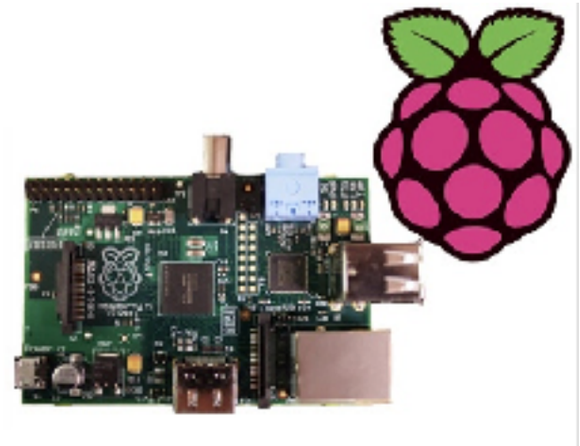
Use Case: Privacy Camera

Remove privacy sensitive features from video stream

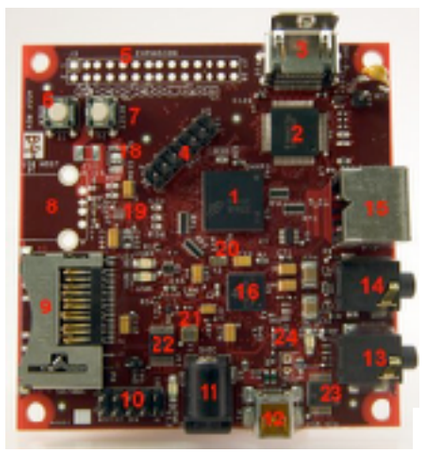
1. Authorization required to obtain raw video from camera (e.g., on the same LAN)
2. SECE installs a feature removal app on the camera
3. App removes privacy sensitive features (B&W, crop, binary)
4. App streams processed data to cloud for further processing



Challenges: Device Heterogeneity



BeagleBoard



Phidgets

Arduino

WebRTC & Distributed IoT Apps

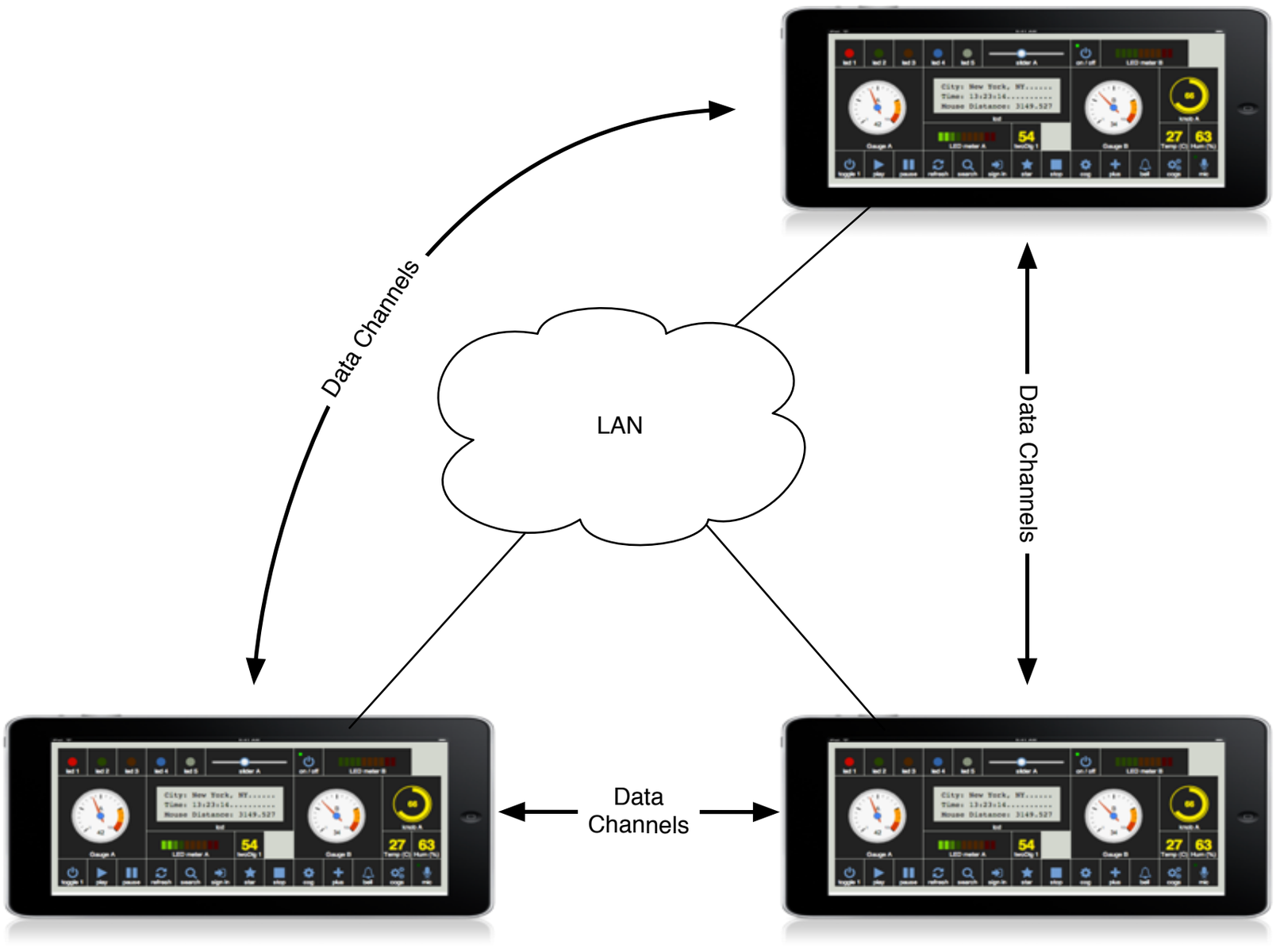
- Enable direct Device-to-Device communication
  - Closed loops, latency, privacy
- Make prototyping without hardware possible
- First class support for browser-enabled devices
  - UI, programmability, storage, communication
- Component design

Web-based User Interface

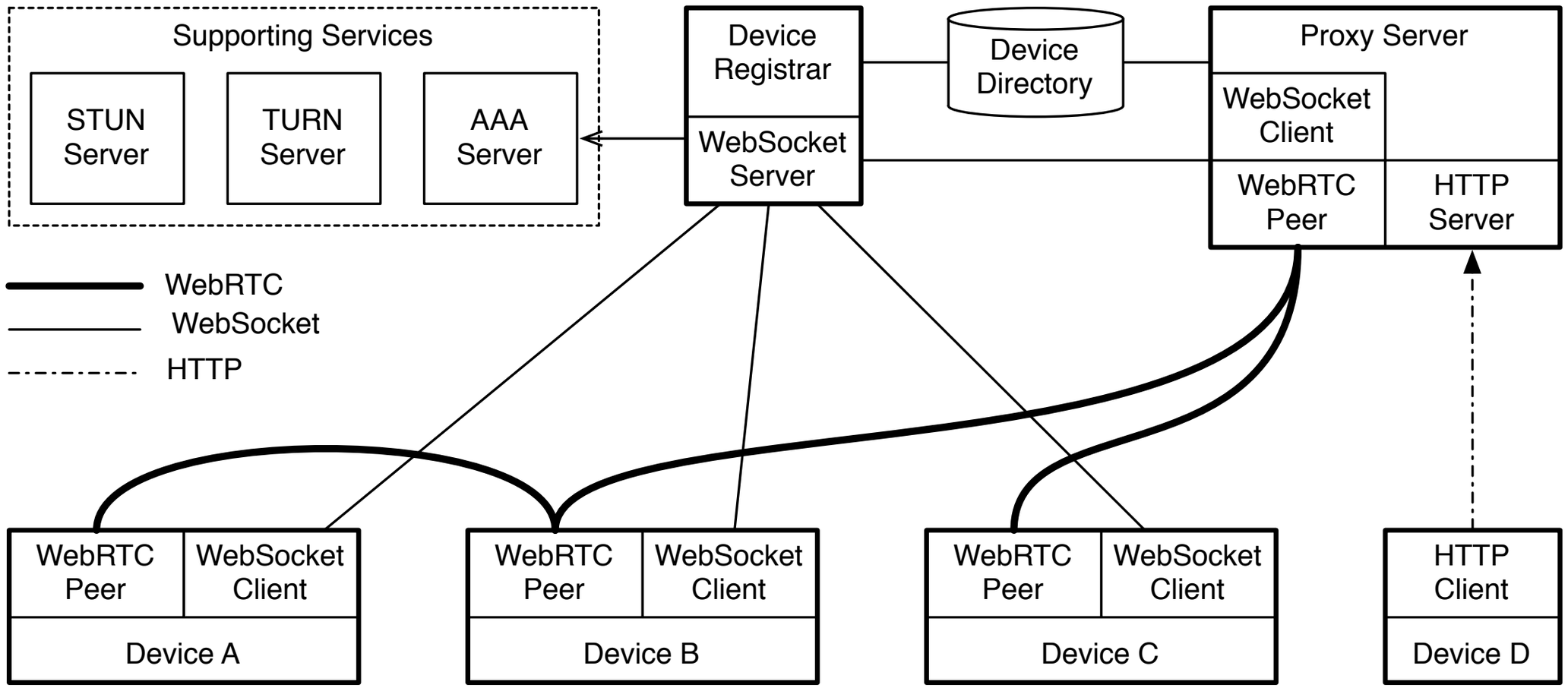
Web-based User Interface

- Use HTML5 and WebRTC for communication
- Virtual widgets implement inputs and outputs
- Gauges, LEDs, Buttons, A/V inputs/outputs
- Runs on a tablet with a recent browser
- Modes of operations
  - MVC: multiple views of a panel (synchronized) (requires node.js server)
  - Only-one instance (fails to open second time)
  - Bound to a specific device

Direct Device-to-Device Communication



Network Architecture (for WebRTC)



IoT Device Emulation

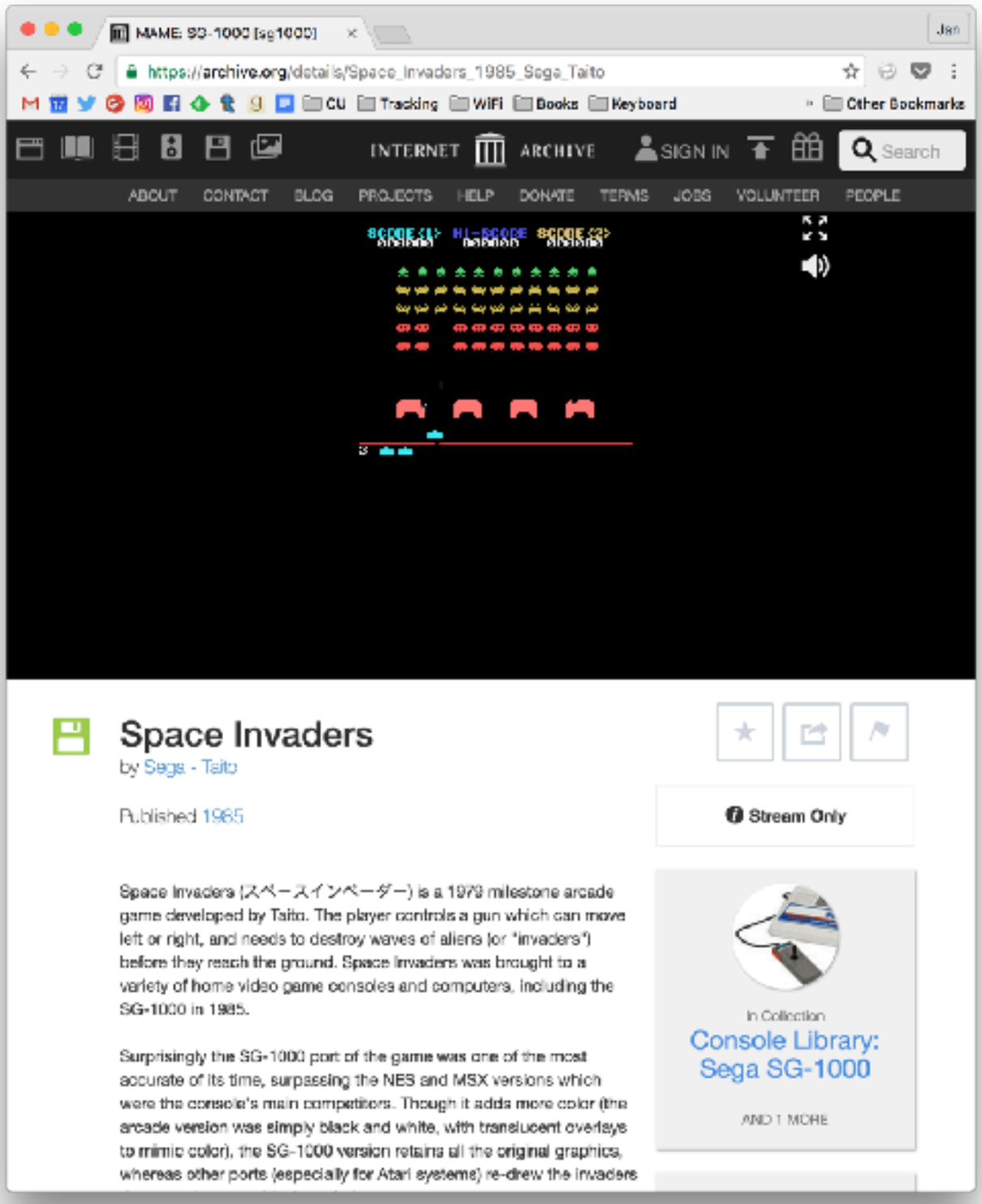
- Emulate simpler IoT devices in JavaScript
  - Arduino, Teensy, ZigBee, and similar
  - Run program for the device via Emscripten
    - Connect I/O ports to virtual HTML5 ports
- Inspiration: Internet Arcade
- Why JavaScript?
  - Available everywhere (tablets, laptops, Raspberry PI, Node)
  - Interactive (UI capabilities)

Inspiration: Internet Arcade

- An effort to preserve computer history
- 900 classic games in your browser
- Emulates arcade console hardware in JavaScript
- Runs unmodified binary images of games

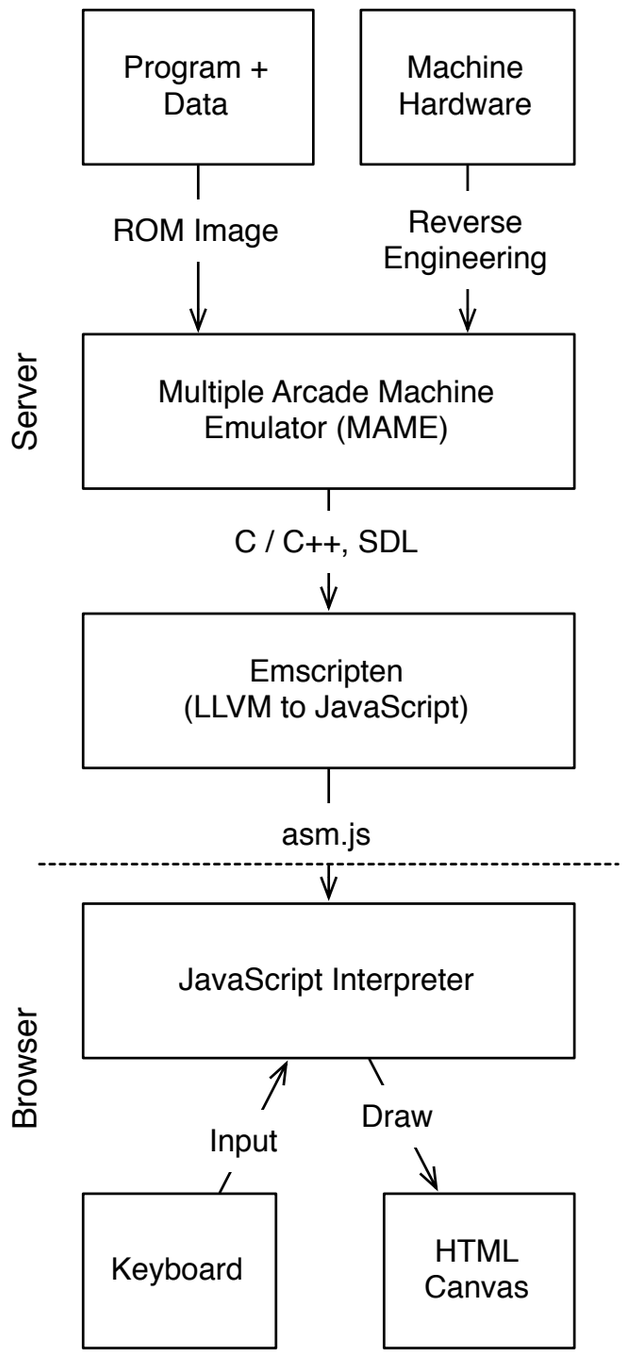
http://www.theverge.com/2014/11/2/7147505/the-internet-arcade-puts-900-classic-games-right-in-your-web-browser

Internet Arcade



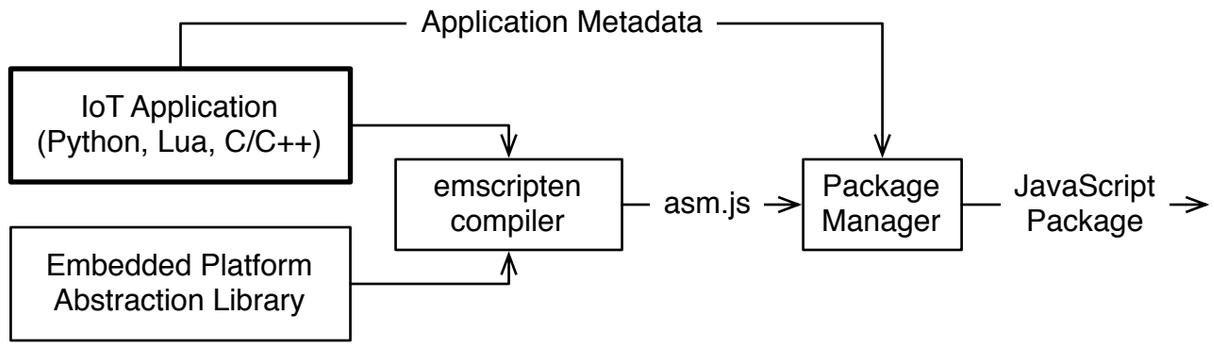
JavaScript IoT Device Emulation

Work in Progress

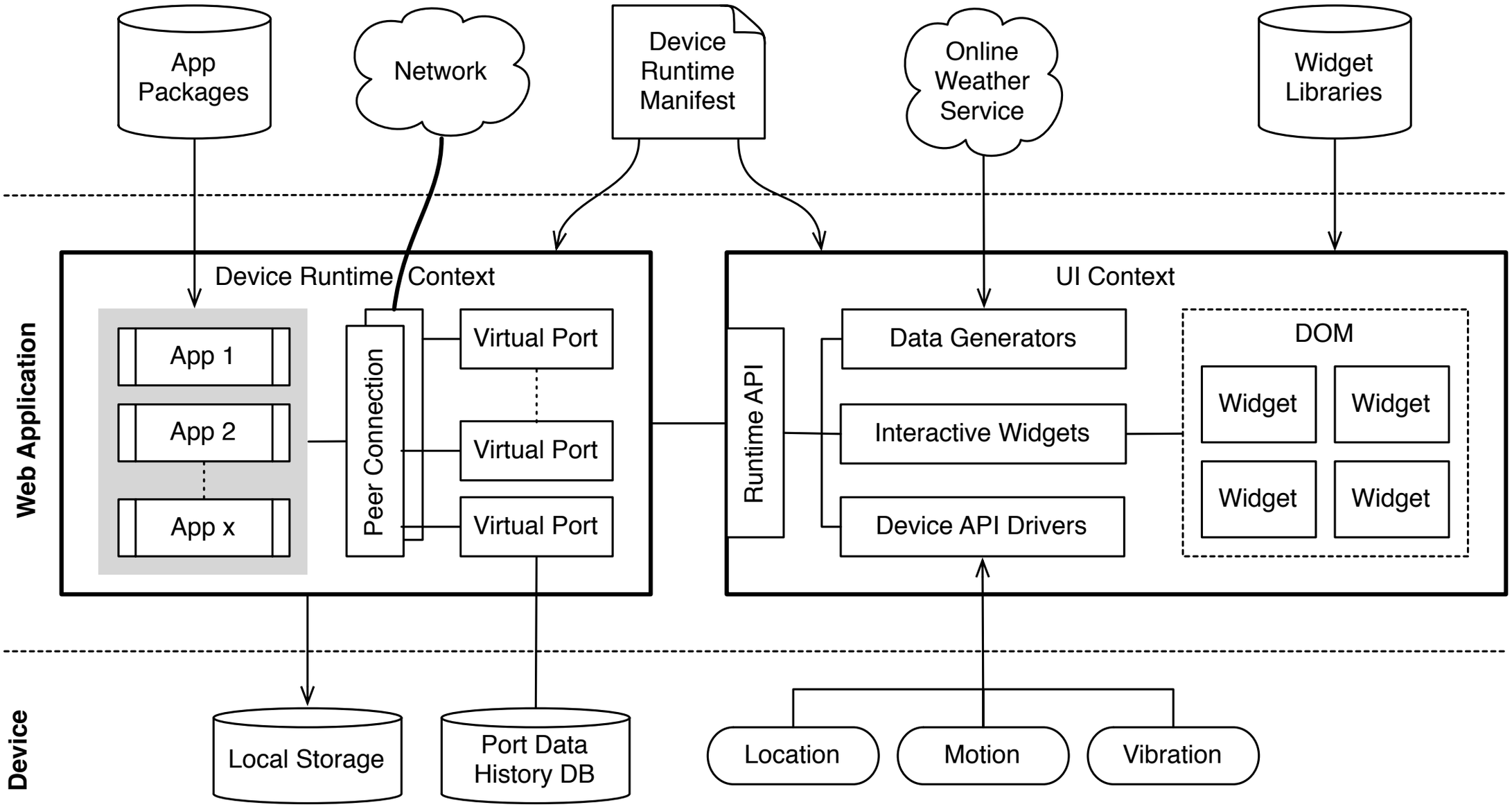


Internet Arcade

IoT Devices



SECE JS Framework



Summary

- End-to-end programmable IoT applications
  - Privacy, security, latency, resiliency benefits
  - Hard to design, prototype, and test
- HTML5 + WebRTC + JavaScript to the rescue
  - First-class virtual ports modeled after physical ports
  - WebRTC for direct communication between ports
  - IoT device emulation in JavaScript feasible