### **FRED**: A Hosted Data Flow Platform for the IoT

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Mashups of Things and ABIs

Mashups of Things and APIs

# Data Flow Programming

- Natural fit for common IoT development tasks:
  - configurable black box *nodes* wired together into flows
  - connecting *things*, IoT infrastructures and other services
  - visual, flexible and easy to use; proven for music, toys, engineering, integration
- Web of Things Toolkit (WoTKit) (2012)
  - Device management, time series data storage and visualization dashboards
  - **Processor -** multi-user, cloud hosted data flow programming tool to integrate devices and cloud services
- **Node-RED** introduced for edge devices such as Raspberry Pi for device-level integration







- Open source web-based tool for 'wiring up' hardware (e.g. sensors and actuators connected to a Pi) to various protocols and APIs.
- Browser based visual editor and run time both implemented using Javascript
- Large and growing community with *many* contributors of node packages.





## Node RED Architecture

- Editor generates JSON flow; all 'tabs' are part of a single file.
- On deploy to runtime, JSON flow is parsed, nodes instantiated.
- Each node is a Node.js EventEmitter object; on 'send' call, node looks up wired nodes and calls emit.input(msg) on downstream nodes.
- By calling EventEmitter API, uses Node.js' single threaded Event Loop.
- Concurrency achieved using callbacks executed after long running operations (e.g. I/O).



Based on <u>http://www.aaronstannard.com/post/</u> 2011/12/14/Intro-to-NodeJS-for-NET-Developers.aspx



# Why FRED?

- Make NR easily available for multiple users
  - NR is single threaded, single user system, limited access control
  - Requires manual configuration and command line install to get started
  - Manage and monitor instances for users
  - Control and limit instance resource use
  - Install and remove node packages for instances
  - minimize cloud resources for system as a whole





### FRED Architecture

- 'Smart proxy' that creates and manages instances of NR for authorized users
  - start/stop, view logs, install nodes, monitor execution
- FRED Proxy: user and admin management UI, and proxies to Node-RED instances
- Billing System: login, registration payments systems integration
- FRED IS: create, start and stop Node-RED containers/processes
- Node-RED runs without modification



### User Interface



### Node Management

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### Example NR Flows



### Dashboards





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### What do you use FRED for?

- >3000 users; >10 per day sign up.
- ~60% learning about Node-RED
- ~30% personal projects.
- ~ 8% work related projects

Home automation Remote Monitoring Web services/APIs

What industry or area of interest are you using FRED for? (select all that apply)



### Lessons Learned

#### Smart proxy approach benefits

- Node-RED deployed as multi-user system without changes. May be generalized to other services.
- Permits fine-grained access control to Node-RED UI and flows (e.g. public and private HTTP inputs) by URL

#### **Node.js runtime is memory hungry**. 85MB+ RAM per instance ~\$1.00 per month

- Package (node) management important to minimize memory.
- Added node count limits and auto shut down for non-paying users.

#### Appeals to DIY'ers, makers, educators, students ... mostly

- low cost, quick and easy to set up... but many users will try it out and leave.
- Learning tool can focus on NR instead of set up and installation
- Can be bundled with IoT hardware and platforms as rules engine & app prototyping

### Future work

#### Simplify flow development

• Simpler nodes and sample flows for common use cases

#### Scalability

- Use cluster container management system Docker Swarm
- Scale NR to use multiple cores & machines sharing flow state & MQTT subscriptions

#### Support different instance deployments

- Prototype, test, and production instances higher performance, replication, backup
- Multiple cloud and container systems e.g. Cloud Foundry, AWS VMs, Google Cloud

#### Sharing instances

• In an organization with multiple users - flows, dashboards; public dashboards

#### Distributing flows to devices...



## Distributed Node-RED

- Flows that coordinate multiple hosts: in the cloud, on servers, gateways and devices.
- Associate sub-flows with individual or groups of devices.
  - 'Server' flows must run on a server, 'Device' flows on a specific device, or groups of devices.
  - Local wires connect nodes on same device, remote wires connect flows between devices directly, using gateways or cloud.
  - Association may change dynamically.



## Early Prototype





# DNR Open Issues

- Devices labelled explicitly -> how can we specify constraints of device associated with sub-flows?
- How to deal with dynamic constraints (e.g. location and mobility)?
- How to visualize/simulate distributed deployment and execution?



## Summary

- Data flow programming useful for many IoT tasks
- FRED enables data flows to be provisioned quickly and easily
  - takes advantage of contributions of the Node-RED community without changes
- Future work includes Distributed Node-RED for deployment of flows in the cloud, servers and devices





### Thank you!

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