

Android Things: Adding Intelligence to the Network Edge

Timothy J. Salo
Salo IT Solutions, Inc.
salo <at> saloits <dot> com

Android Things

Today's Presentation

- Focus on capabilities of Android Things
 - What it is, what it can do
 - When, where, and why you might employ it
 - A few personal observations
- Examine
 - Adding intelligence at the network edge
 - Adding Artificial Intelligence (AI) at network edge (*very* briefly)

Android Things

Today's Presentation

How to *develop* Android Things apps and systems will be glossed over

- See references

Experience using Android Things to develop embedded software will be largely avoided

- See references

Android Things

Today's Presentation

`<https://www.saloits.com/papers/AndroidThingsDevFestMN2019.pdf>`

`<https://github.com/tjsalo/>`

Android Things

Today's Presentation

- See also (not covered here):
“Getting Started With Android Things: Your first Android Things App”
<<https://www.saloits.com/papers/AndroidThingsGettingStarted.pdf>>

Dated, but still useful

Android Things

Today's Presentation

- See also (not covered here):
“Interfacing Android Things with an Arduino:
Real-World Experience and Observations”
<<https://www.saloits.com/papers/InterfacingAndroidThingsIoTDevfest2019.pdf>>

Android Things

Disclaimer

- I do not work for Google
 - I have never worked for Google
 - I have no inside information
- Opinions are solely my own
 - Not those of any agency that has funded me or might fund me

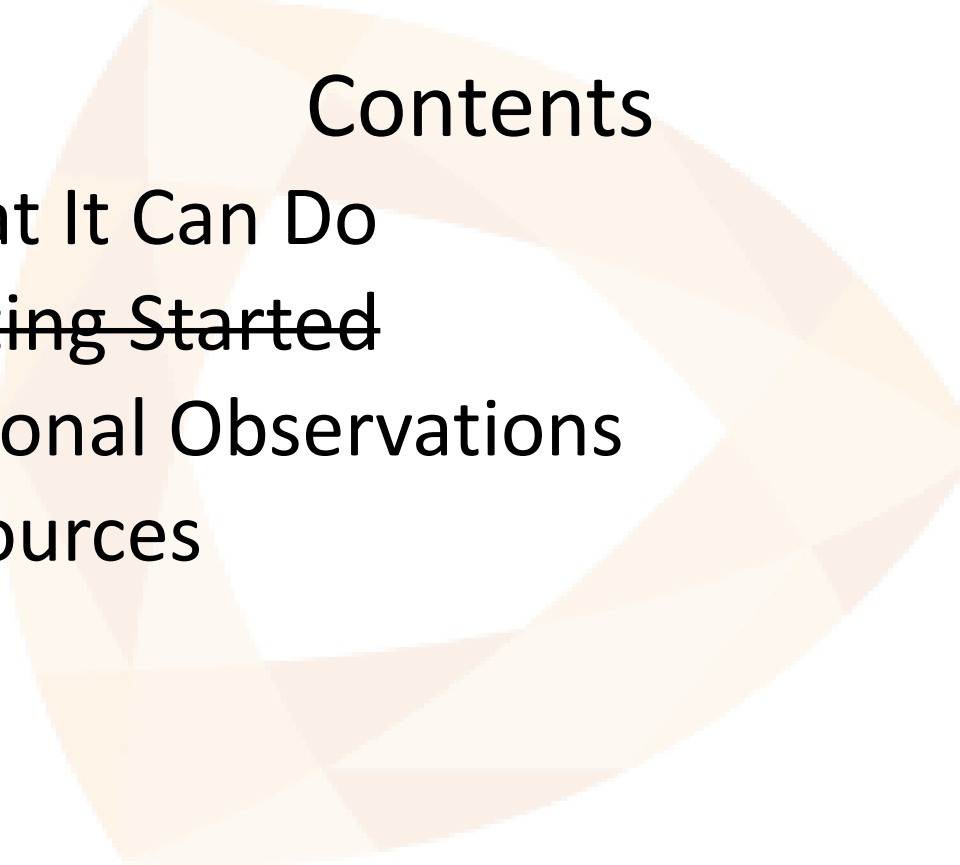
Android Things

Contents

- I. What It Can Do
- ~~II. Getting Started~~
- III. Personal Observations
- IV. Resources

Android Things

Contents

- 
- 
- I. What It Can Do
 - ~~II. Getting Started~~
 - III. Personal Observations
 - IV. Resources

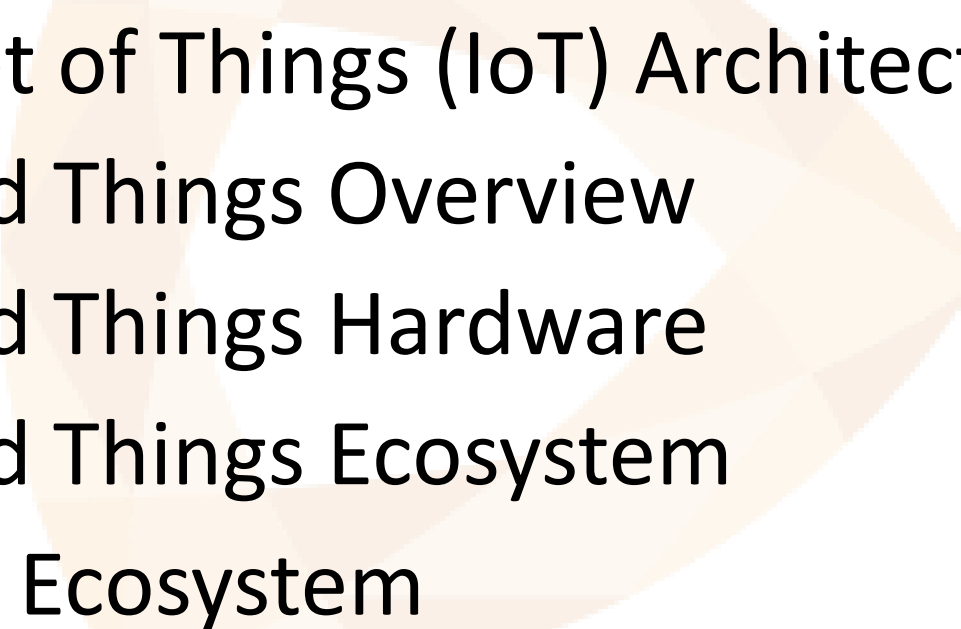
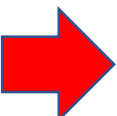
Android Things: What It Can Do

Contents

- Internet of Things (IoT) Architectures
- Android Things Overview
- Android Things Hardware
- Android Things Ecosystem
- Google Ecosystem

Android Things: What It Can Do

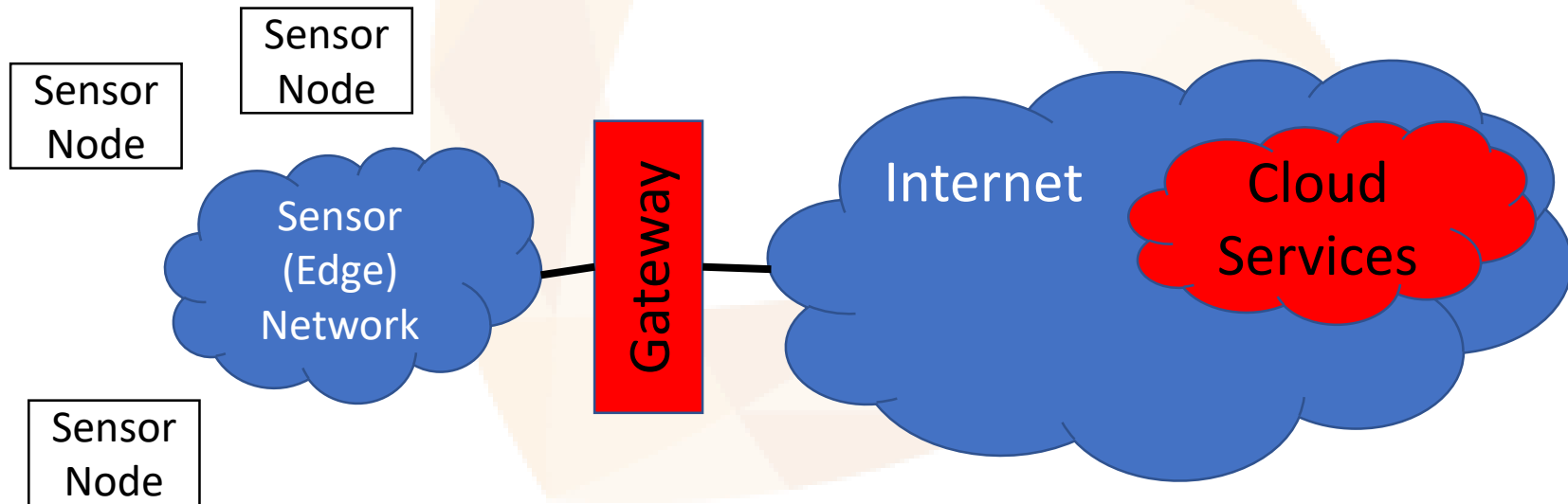
Contents

- 
- 
- Internet of Things (IoT) Architectures
 - Android Things Overview
 - Android Things Hardware
 - Android Things Ecosystem
 - Google Ecosystem

Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Early three-level architecture



Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Early three-level architecture

- Sensor Nodes
 - Sensors (or actuators) with limited capability processors
- Sensor (edge) network
 - Typically low-power wireless

Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Early three-level architecture

- Gateway
 - Connect sensor nodes to Internet
 - Translate between sensor data, sensor network protocols and Internet formats
 - Initially, limited processing and storage

Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Early three-level architecture

- Internet
- Cloud Services
 - Could alternatively be private data center
 - Data processing, analysis, storage, etc.

Android Things: What It Can Do

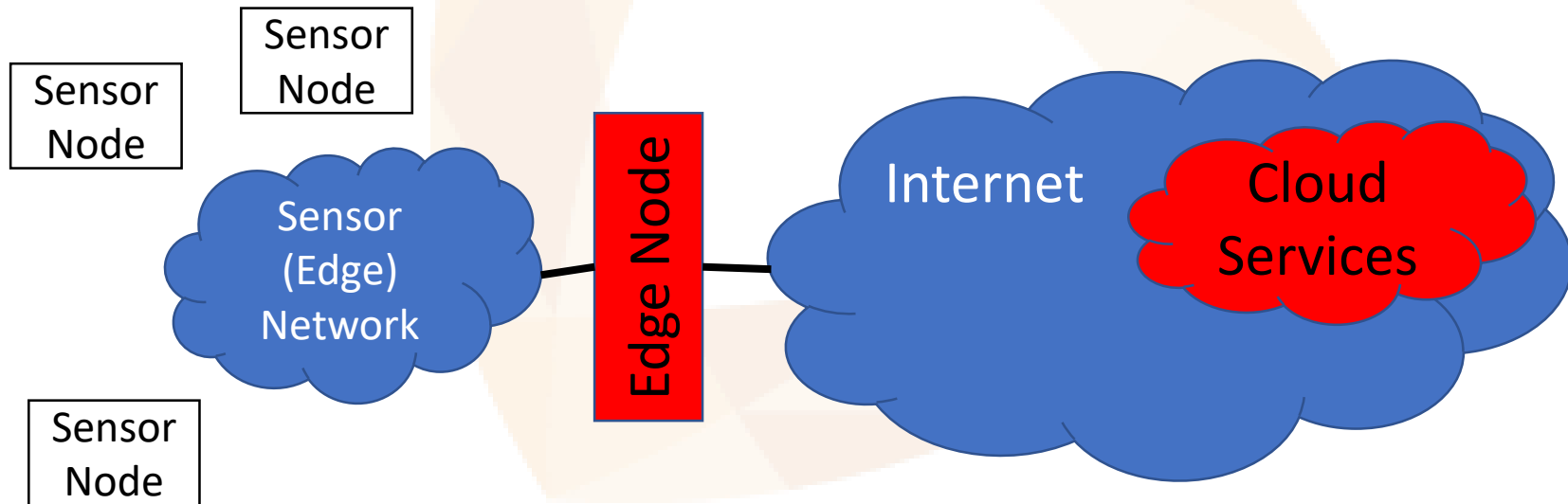
Internet of Thing (IoT) Architectures

Early three-level architecture

- Limitations
 - High data volume over Internet
 - Limited autonomy
 - Dependent on Internet connectivity
 - High Latency
 - Privacy concerns

Android Things: What It Can Do

Internet of Thing (IoT) Architectures
Emerging three-level architecture



Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Emerging three-level architecture

- Edge Node
 - Deploy more compute power at edge of sensor network
 - “Edge computing”
 - “Fog computing”

Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Emerging three-level architecture

- Edge/Fog computing
 - More data analysis at edge of network
 - More data storage at edge of network
 - Possible sensor integration at edge
 - Requires more compute power, storage

Android Things: What It Can Do

Internet of Thing (IoT) Architectures

Emerging three-level architecture

- Benefits of Edge/Fog computing
 - Local computation / analysis / decisions
 - Less data transported to Internet
 - Lower latency for local operations
 - Increased autonomy / reliability
 - Increased privacy

Android Things: What It Can Do

- Contents
 - Internet of Things (IoT) Architectures
 - Android Things Overview
 - Android Things Hardware
 - Android Things Ecosystem
 - Google Ecosystem

Android Things: What It Can Do

Android Things Overview

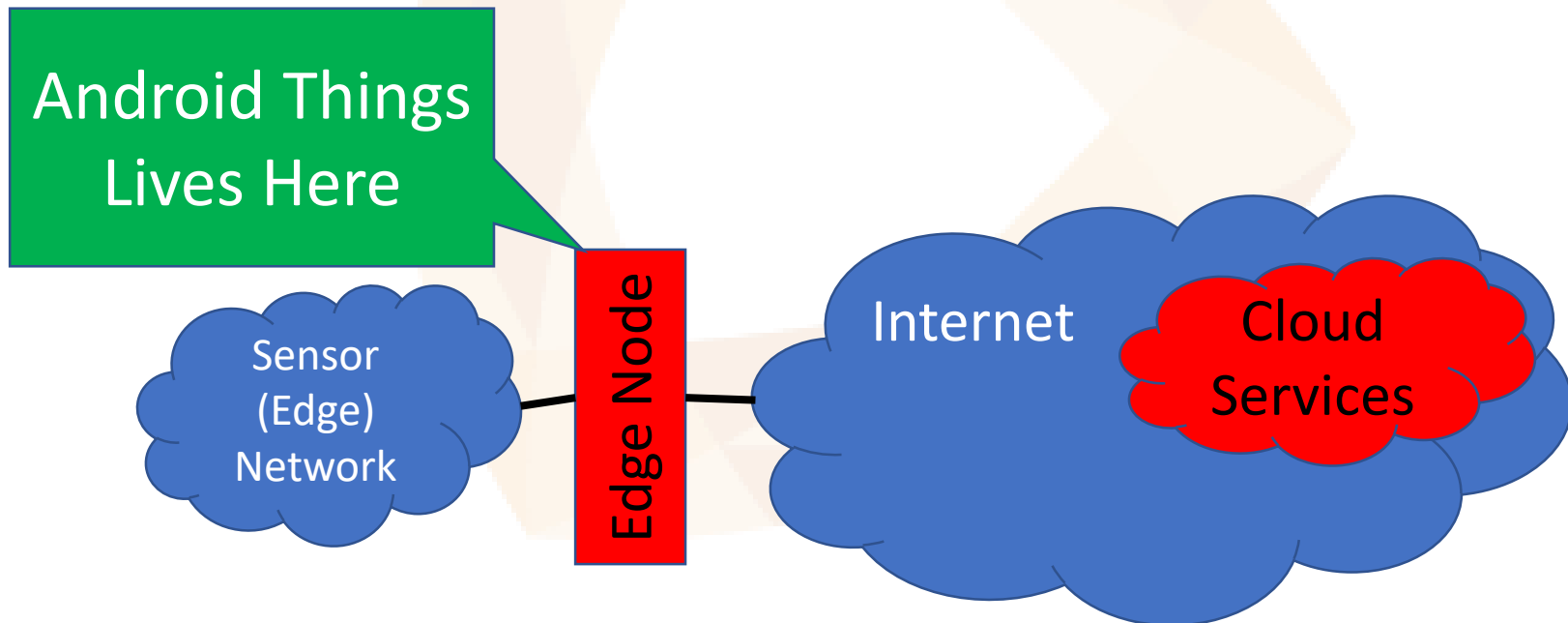
Google's software solution for Internet of Things (IoT) and embedded [edge] devices

- Variant of Android tailored for IoT and embedded devices
- Extends Android to another form factor
 - Mobile, wearable, TV, auto, IoT, ...

Android Things: What It Can Do

Android Things Overview

Android Things lives at network edge



Android Things: What It Can Do

Android Things Overview

Google's Edge Device Solution

- Adds intelligence at edge of sensor network
- Combined with other Google services, can provide broad solution

Android Things: What It Can Do

Android Things Overview

Google's Edge Device Solution

- Simplifies development, deployment, management of IoT / embedded prototypes, devices, products, systems

Android Things: What It Can Do

Android Things Overview

Android Things is a variant of Android

- Some Android APIs not available
 - Graphical User Interface (GUI) optional
 - Many GUI APIs not supported
 - A few other APIs, features not supported
- It's still Android!

Android Things: What It Can Do

Android Things Overview

Android Things is a variant of Android

- New Android Things APIs, features support embedded / IoT devices
 - Home activity
 - Device updates
 - 6LoWPAN / Open Thread

Android Things: What It Can Do

Android Things Overview

Android Things is a variant of Android

- New Android Things APIs, features support embedded / IoT devices (continued)
 - Peripheral I/O APIs
 - User-space driver
 - Set date / time

Android Things: What It Can Do

Android Things Overview

New Android Things APIs, features

- Home activity
 - App that runs when device booted
 - There is no human to start an app!

Android Things: What It Can Do

Android Things Overview

New Android Things APIs, features

- Device updates
 - Google can update your device software over-the-air

Android Things: What It Can Do

Android Things Overview

New Android Things APIs, features

- 6LoWPAN / OpenThread
 - Google/Nest's home automation protocols
 - IEEE 802.15.4
 - Vaguely similar to ZigBee

Android Things: What It Can Do

Android Things Overview

New Android Things APIs, features

- Peripheral I/O APIs
 - Support for many standard embedded interfaces
 - GPIO, PWM, I²C, SPI, UART

Android Things: What It Can Do

Android Things Overview

New Android Things APIs, features

- User-space drivers
 - Develop drivers in user space

Android Things: What It Can Do

Android Things Overview

New Android Things APIs, features

- Set date / time
 - Automagically, over-the-air

Android Things: What It Can Do

Contents

- Android Things Overview
- ➔ • Android Things Hardware
- Android Things Ecosystem
- Google Ecosystem

Android Things: What It Can Do

Android Things Hardware

- Android Things employs a “SOM [System on Module] architecture”

Android Things: What It Can Do

Android Things Hardware

- A SOM is a small board that contains a processor, memory, etc.
 - Not a complete embedded computer
- Plugs into a baseboard that contains I/O connectors, etc.
- SOMs are hard to design; baseboards, less so

Android Things: What It Can Do

Android Things Hardware

- SOM modules and baseboard

https://www.innocomm.com/product_inner.aspx?num=2166

Android Things: What It Can Do

Android Things Hardware

- Google and SOM vendor develop SOM support
 - Board Support Package (BSP)
- IoT / embedded product developers create software (applications) for SOM-based development systems

Android Things: What It Can Do

Android Things Hardware

- Benefits of SOM architecture
 - Simplify software development
 - Develop on SOM development boards
 - Simply prototype development
 - Develop only SOM carrier board
 - Build cost-reduced hardware later, if warranted

Android Things: What It Can Do

Android Things Hardware

- Android Things runs on a (currently) *[very]* restricted set SoMs
 - Google must certify production hardware platform
 - Google certifies SoM, not end device
 - Support for ~~more~~ SOMs promised
 - Development boards available for SOMs

Android Things: What It Can Do

Android Things Hardware

- Android Things supports limited number of SOMs
 - “Production Platforms”
 - “Development Platforms”

Android Things: What It Can Do

Android Things Hardware

- Production Platforms
 - Certified by Google
 - Meet security requirements
 - Minimum three years updates
 - Stability updates
 - Security updates

Android Things: What It Can Do

Android Things Hardware

- Production Platforms
 - Currently supported SOMs
 - 512 MB – 2 GB RAM
 - 4MB storage
 - 32- or 64-bit ARM CPU
 - Quad- or octa-core CPU
 - “Embedded supercomputers”

Android Things: What It Can Do

Android Things Hardware

- Production Platforms
 - Currently supported SOMs
 - These are hefty CPUs
 - Android Things does *not* support small embedded processors
 - Based on Linux
 - Requires MMU, etc.
 - No 8- or 16-bit processors

Android Things: What It Can Do

Android Things Hardware

- Production Platforms
 - Currently “supported” SOMs
 - NXP i.MX8M
 - Qualcomm SDA212
 - Qualcomm SDA624
 - MediaTek MT8516

Android Things: What It Can Do

Android Things Hardware

- Production Platforms
 - Currently “supported” SOMs
 - NXP i.MX8M “coming soon”
 - Qualcomm SDA212 “coming soon”
 - Qualcomm SDA624 “coming soon”
 - MediaTek MT8516 “coming soon”
 - As of February 2019

Android Things: What It Can Do

Android Things Hardware

- Development Platforms
 - Not certified by Google
 - Don't meet security requirements
 - Might (or might not) receive
 - Stability updates
 - Security updates
- Will receive feature updates

Android Things: What It Can Do

Android Things Hardware

- Development Platforms
 - Android Things starter kits available
 - CPU
 - Wi-Fi
 - Display (!)
 - Peripheral board (Rainbow HAT)
 - Case (cardboard)

Android Things: What It Can Do

Android Things Hardware

- Development Platforms
 - Pro tip:
 - Get an Android Things starter kit
 - Or, assemble one yourself (see below)
 - Starter kits:
 - Are relatively inexpensive
 - Are likely to work right of the box

Android Things: What It Can Do

Android Things Hardware

- Development Platforms
 - Android Things supports RPi 3 B
 - But, not Raspberry Pi 3B+
 - Inexpensive, available, great for learning
 - Not a SOM
 - Hard to build a product on Raspberry Pi 3

Android Things: What It Can Do

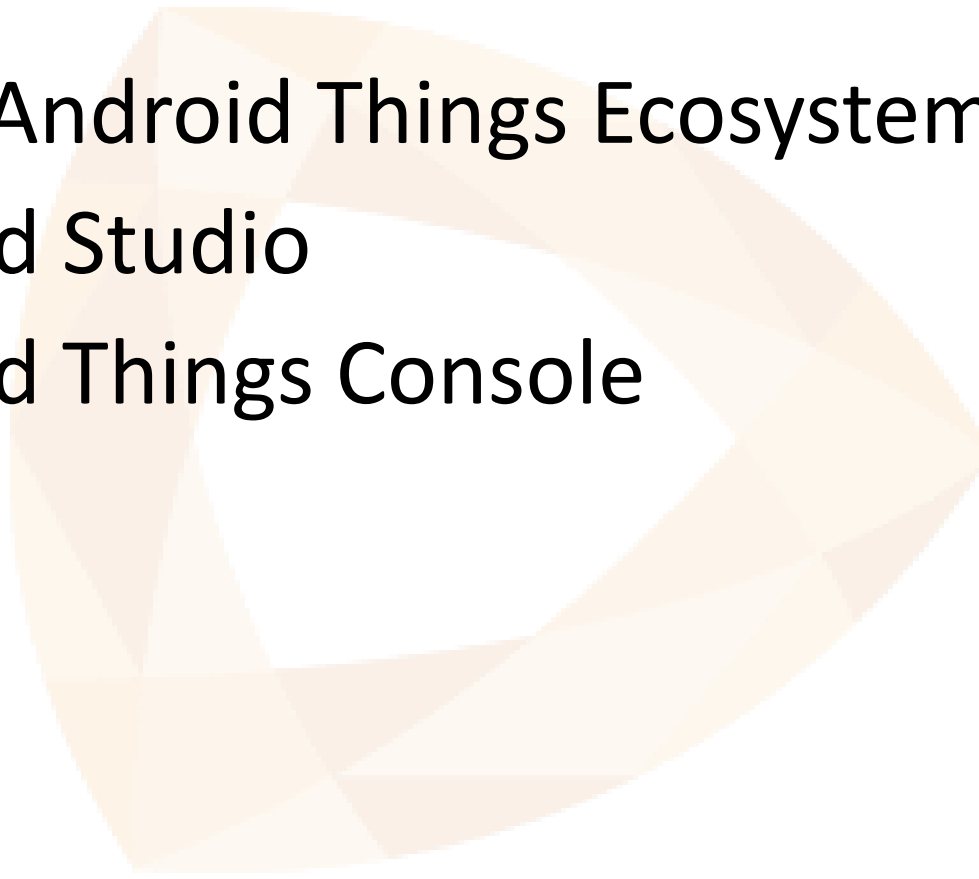
Contents

- Android Things Overview
- Android Things Hardware
- ➔ • Android Things Ecosystem
- Google Ecosystem

Android Things: What It Can Do

Android Things Ecosystem

- Android Studio
- Android Things Console



Android Things: What It Can Do

Android Things Ecosystem

Android Studio

- Android Things integrated with Android Studio!
 - The Integrated Development Environment (IED) used to develop Android apps
 - adb, etc., etc.

Android Things: What It Can Do

Android Things Ecosystem

Android Studio

- Android Things integrated with Android Studio
 - Android Things: just another Android variant
 - Just another check box to build Android Things apps

Android Things: What It Can Do

Android Things Ecosystem

Android Studio

- Google says: Android developers can do IoT / embedded development
 - Some truth to this assertion
 - See last week's IoT Devfest presentation:
<<https://www.saloits.com/papers/InterfacingAndroidThingsIoTDevfest2019.pdf>>

Android Things: What It Can Do

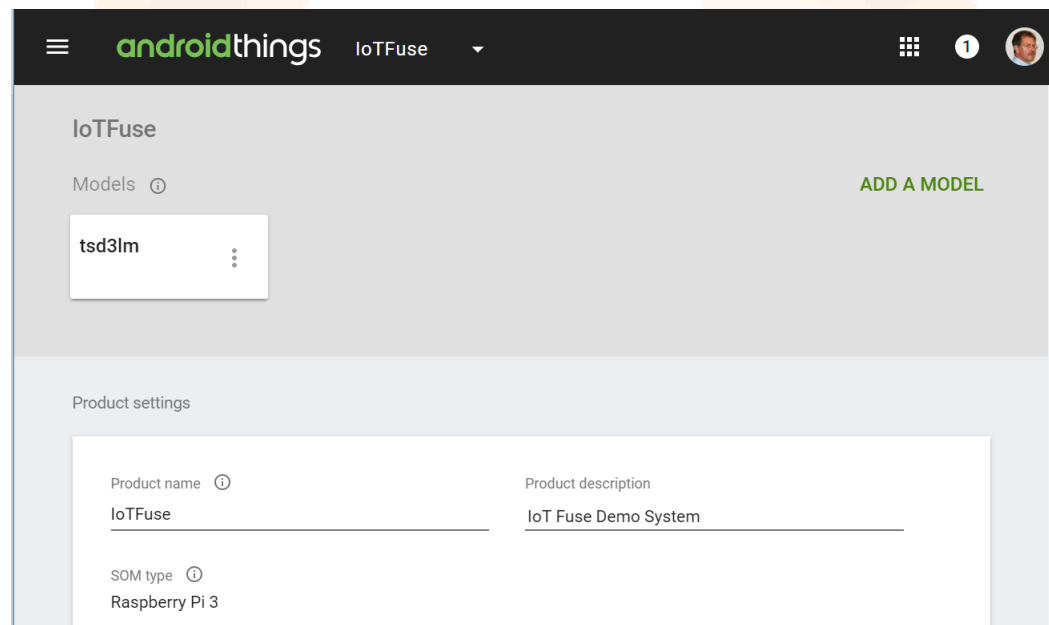
Android Things Ecosystem

Android Things Console

- Google service to support developing / deploying / managing Android Things devices

Android Things: What It Can Do

Android Things Ecosystem Android Things Console

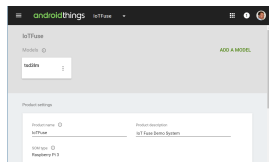


Android Things: What It Can Do

Android Things Ecosystem

Android Things Console

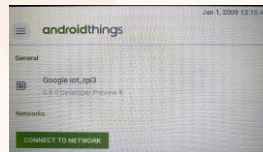
- Create Android Things system image



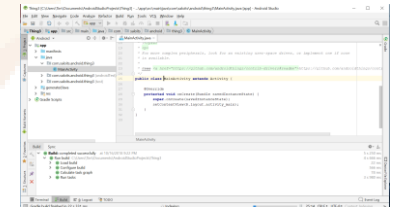
Create System Image
(Android Things Console)

App

System
Image



Android Things Device



Develop App
(Android Studio)

Android Things: What It Can Do

Android Things Ecosystem

Android Things Console

- You develop Android Things apps
- **Google creates system images!**
 - You can't modify Android Things
 - You can't have a private version of Android Things
 - No, you can't run your own kernel
 - Google may deploy system image

Android Things: What It Can Do

Android Things Ecosystem

Android Things Console

- Also provides
 - Device management
 - Analytics
 - On-the-air updates

Android Things: What It Can Do

Contents

- Android Things Overview
- Android Things Hardware
- Android Things Capabilities
- Android Things Ecosystem
- ➔ • Google Ecosystem

Android Things: What It Can Do

Google Ecosystem

- Android Things is part of the Google ecosystem
 - Google Cloud IoT
 - Topic for another day
 - ...
 - Google Artificial Intelligence (AI) products
 - TensorFlow

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow

- Open-source machine learning framework
- Originally developed at Google

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow Lite

- Smaller version of TensorFlow for mobile and embedded devices
- TensorFlow Lite can run under Android Things!

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow Lite

- Android Things systems may distribute machine learning system
 - Preliminary processing on Android Things edge node
 - Compute-heavy processing in cloud

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow Lite

- Classic examples of distributed TensorFlow (or any ML) models:
 - Edge node finds license plate; cloud reads license plate
 - Edge node finds face; cloud recognizes face

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow Lite

- See:
 - Building TensorFlow on Android
 - <https://www.tensorflow.org/lite/tfmobile/android/build>

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow Lite

- See Google Codelabs
 - TensorFlow for Poets 2: TFLite Android
 - <https://codelabs.developers.google.com/codelabs/tensorflow-for-poets-2-tflite/index.html>

Android Things: What It Can Do

Google Ecosystem

Google TensorFlow Lite

- See Google Codelabs
 - Android Things Image Classifier
 - <https://codelabs.developers.google.com/codelabs/androidthings-classifier/index.html>

Android Things

Contents

- I. What It Can Do
-  II. ~~Getting Started~~
- III. Observations
- IV. Resources

Android Things: Getting Started

How to Get Started

1. Acquire Hardware
2. Flash Android Things system software
3. Connect Raspberry Pi to network
4. Connect Android Studio to Raspberry Pi
5. Run your first Android Things app
6. Develop Android Things apps

Android Things: Getting Started

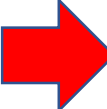
- See Related Presentation

“Getting Started With Android Things: Your first Android Things App”

<<https://www.saloits.com/papers/AndroidThingsGettingStarted.pdf>>

Android Things

Contents

- I. What It Can Do
- ~~II. Getting Started~~
-  III. Personal Observations
- IV. Resources

Android Things: Personal Observations

Disclaimer

- I do not work for Google
 - I have never worked for Google
 - I have no inside information
- Opinions are solely my own
 - Not those of any agency that has funded me or might fund me

Android Things: Personal Observations

Whither Android Things?

Will Android Things become a useful tool for embedded programming?

- I would love to see Android Things become brilliantly successful
- But...

Android Things: Personal Observations

Whither Android Things?

The Android Things ecosystem has many nice capabilities

- Android Studio
 - Leverage Android developer expertise / documentation / ...
 - Leverage Android code base / examples / ...
 - Rich IDE
 - adb
 - ...

Android Things: Personal Observations

Whither Android Things?

The Android Things ecosystem has many nice capabilities

- Over-the-air (OTA) software updates
 - Addresses one of the more vexing IoT problems

Android Things: Personal Observations

Whither Android Things?

The Android Things ecosystem has many nice capabilities

- Android Things Console
 - Has potential
 - Feels like a prototype

Android Things: Personal Observations

Whither Android Things?

The Android Things ecosystem has many nice capabilities

- User-level device drivers
 - Capability has potential
 - Doesn't appear to be easily (user) extensible
 - Limited insight into kernel / hardware state
 - May be difficult to debug / repair

Android Things: Personal Observations

Whither Android Things?

Will Android Things become a useful tool for embedded programming?

- Current focus on big iron (“supercomputers”)
 - Multi-core, GHz processors with half-a-gigabyte or more
- Seems unlikely to ever be useful for MCUs
- Useful on generic CPUs?
- Useful outside of Google ecosystem?

Android Things: Personal Observations

Whither Android Things?

- Android Things 1.0 released May 7, 2018
- It feels to me like an early product
 - Needs to support more SOMs
 - Needs to certify ~~more~~ some SOMs
 - Needs more features, more APIs
 - ...

Android Things: Personal Observations

Whither Android Things?

- Blog “Say Hello to Android Things 1.0”
 - May 7, 2018
- Blog “All the (Android) Things at Google I/O”
 - May 25 2018
- Last blog entry...

Android Things: Personal Observations

Whither Android Things?

- Android Things ~~is~~ has been a hot topic at Google
 - Several Android Things sessions at Google I/O 2017
 - Twelve IoT sessions at Google I/O 2018
 - Google I/O 2019?

Android Things: Personal Observations

Whither Android Things?

- Android Things seems to be [has been?] a big deal for Google
 - Google handing out Android Things developer hardware kits at conferences
 - Products using Android Things announced at Consumer Electronics Show (CES) in January 2018

Android Things: Personal Observations

Whither Android Things?

Announced at CES 2018

- JBL Link View
- LG ThinQ WK7
- Lenovo Smart Display
 - Qualcomm Snapdragon 624
- iHome iGV1

Android Things: Personal Observations

Whither Android Things?

Will Android Things become a useful tool for embedded programming?

- Focus appears to be on consumer electronics devices:
 - smart displays (large and small)
 - home automation hubs

Android Things: Personal Observations

Whither Android Things?

Will Android Things become a useful tool for embedded programming?

- In my view, Google needs an edge computing solution
 - Important for Google IoT Cloud

Android Things: Personal Observations

Whither Android Things?

Will Android Things become a useful tool for embedded programming?

- Lots of competition in these spaces
- Even within Google
 - Chrome OS
 - Fuchsia
 - Cloud IoT Edge / Linux

Android Things: Personal Observations

Whither Android Things?

Should I Use Android Things?

- Sure, it offers some interesting features
- Required development hardware is cheap

Android Things: Personal Observations

Whither Android Things?

Should I bet my product on Android Things?

- Are you a multi-billion dollar consumer electronics firm?
- Do you expect your consumer electronics product to sell millions or tens-of-millions of units?

Android Things: Personal Observations

Whither Android Things?

Should I bet my product on Android Things?

- Can you partner with Google?
- If you can't answer "yes" to all, I would be cautious.

Android Things: Personal Observations

Whither Android Things?

Should I bet my product on Android Things?

- Can I live with Google-blessed CPUs?
- Can I wait for Google to certify my CPU?

Android Things: Personal Observations

Whither Android Things?

Should I bet my product on Android Things?

- Do you do you need a modified kernel?
- Do you need low-level access to system software?

Android Things: Personal Observations

Whither Android Things?

Should I bet my product on Android Things?

- Are you (will you be) an Android development shop?
- Can you live with the Google ecosystem?

Android Things: Personal Observations

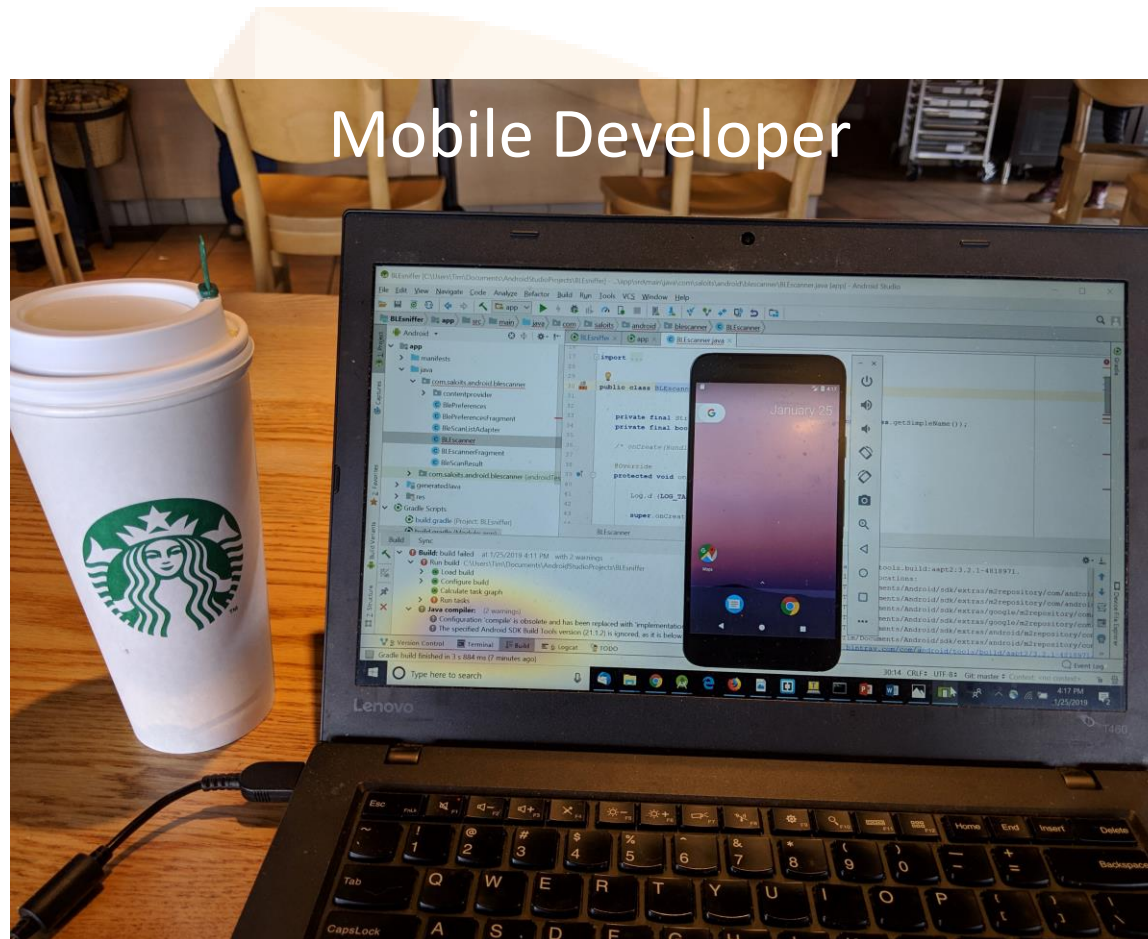
Android Things “Makes embedded development as simple as mobile development has become”

- Dave Smith, Google I/O 2017

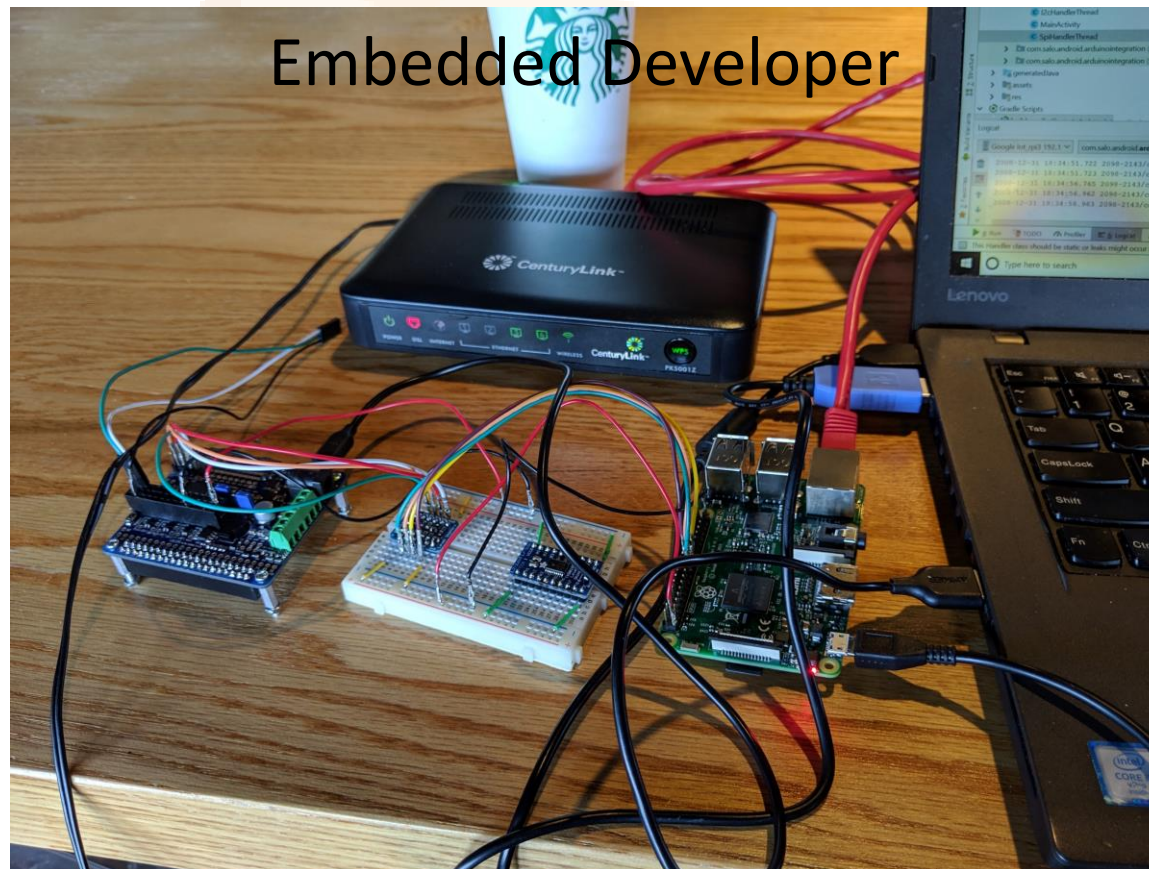
While the Android Things ecosystem demonstrates some potentially useful capabilities, it is no panacea for the challenges that face embedded developers.

- Tim Salo, IoT Devfest 2019

Android Things: Personal Observations

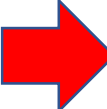


Android Things: Personal Observations



Android Things

Contents

- I. What It Can Do
- ~~II. Getting Started~~
- III. Personal Observations
-  IV. Resources

Android Things: Resources

Android Things Developer Resources

- Android Things on developer.android.com
 - <https://developer.android.com/things/>
- Android Things on GitHub
 - <https://github.com/androidthings>

Android Things: Resources

Android Things Developer Resources

- Google IoT Developers Community (Google+)
 - <https://plus.google.com/communities/107507328426910012281>
- “android-things” on Stack Overflow
 - <https://stackoverflow.com/questions/tagged/android-things>

Android Things: Resources

Google I/O 2018 Presentations

- What's new in Android Things
https://www.youtube.com/watch?v=e_Pl_Npb3-U
- Playlist of Google I/O 2018 IoT videos
<https://www.youtube.com/playlist?list=PLOU2XLYxmsIJQgQfgYDuH8V31HZTtWUBp>

Android Things: Resources

Google I/O 2017 Presentations

- What's New in Google's IoT Platform?
Ubiquitous Computing at Google
 - <https://www.youtube.com/watch?v=Or1uzno8d20>
- Bringing Device Production to Everyone
With Android Things
 - https://www.youtube.com/watch?v=sjpNek_7z-I

Android Things: Resources

Google I/O 2017 Presentations

- From Prototype to Production Devices with Android Things
 - <https://www.youtube.com/watch?v=W6Q8MCyulks>
- Security for IoT on Android Things
 - <https://www.youtube.com/watch?v=U4QBI4PJj8Y>
- Developing for Android Things Using Android Studio
 - <https://www.youtube.com/watch?v=v3Dm5aeuQKE>

Android Things: Resources

Books

Android Things Projects: Efficiently build IoT projects with Android Things.
Francesco Azzola. June 2017. Packt Publishing.

- Somewhat dated, but still useful.

Android Things: Resources

Books

Android Things Quick Start Guide. Raul Portales. August 2018. Packt Publishing.

- Current with Androids 1.0. Several hardware protoboard projects. Overall, useful.

Android Things: Resources

This Presentation

- <https://www.saloits.com/papers/AndroidThingsDevFestMN2019.pdf>