Intelligent Systems and the Evolution of IoT

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The IoT Market is Growing

$4T
Global IoT market by 2025; almost 50% services

121B
Global Smart Home market by 2022

1.8B
Connected Home Devices sold in 2019, outpacing smartphone sales

“In the next 10 years, the Internet of Things revolution will account for nearly two-thirds of the global GDP.”

We Are Approaching The Smart Home Inflection Point

Rich & Geeks
Very Limited Market
- Proprietary. No standards.
- Professional install only.
- Very high cost.
- Limited use cases, device selection.

1-2 Million Households
1-2 Million Households
- Wireless standards.
- Do-it-yourself installation.
- Broadening use cases and device selection.
- Mobile-centric experience allows access & control from anywhere.

2008-2011

Early Adopter
10 Million+ Households
- Do-it-yourself installation.
- Affordable.
- Marketplace of Apps & Services.
- Embedded hubs in home tech & appliance purchase.
- Devices work together seamlessly.

2012-2016

Early Majority
100 Million+ Households
- Hubs in every home (embedded and pre-wired in new home construction).
- Major home services and consumer industry disrupted.
- Connected devices cost less than disconnected devices.

2017-2019

Ubiquity
2020+

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### Moving Beyond open platforms to open eco-systems

<table>
<thead>
<tr>
<th>Samsung + SmartThings</th>
<th>Most Popular Devices</th>
<th>OPEN Interconnected Platforms</th>
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<td><img src="image1" alt="Samsung + SmartThings" /></td>
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- **OPEN**: Developers and Premium Services
As devices increase, each with their own intelligent behaviors, conflicts emerge and become prevalent.
How we got started

• SmartThings has been bringing intelligence to IOT devices since its inception.
  • Add Intelligence to everyday things
  • Simple interactions:
    • Delaying Sprinkler based on rain in weather forecast
    • Vacation lighting
  • Getting things to work together was hard
  • Complexity was embraced by some of our early adopters
• Intelligent Agents have been around for a while
  • Few "Agents" have been adopted by customers (so far)

• SmartApps
  • Can act as an intelligent agent - but can do more (multi-domain)
    • Typically enables a behavior
    • But can extend to complete control of device ecosystems
    • Can enable cloud-cloud integrations
  • Generality can be confusing
  • Hard for SmartApps to work towards common goals
Slow Adoption of IOT by customers

• Compelling scenarios not simple or easily achievable
  • Incremental adoption not granular enough
• Too much up-front work (from installer-roots)
  • Setup what you might use or might be applicable
• Too much friction
• Offer opportunities when they actionable
• Education about what’s possible has been really clunky
• Hard for customers to share / build upon each other
Adoption further impeded by

• ”Dumb” solutions are quite reliable
  • And ... **SECURE**
• Natural buying cycle for home-based devices is slow
• Cost barrier has remained
  • It wasn’t enough to go from 20k -> 2k
• The rush to own the user and the data hasn’t worked for users
  • 61 apps to control devices just within Samsung
  • Every device has its cloud ... sometimes that’s ok, sometimes not!
Transition: Early Adopters -> Early Main-Stream

- 1/3 of the early user base took actions in the IDE
- Each new device added its configuration
  - Alexa, Sonos, Nest ...
- Easy to involve the user to solve problems
  - More decisions surfaced to the user
  - Security encouraged placing complexity with users
- Unexpected actions have increased substantially
  - Poor understanding of cause/effect
  - Generally not self-healing
Role of Intelligence in the adoption of IOT

• Simplified models of adoption have four basic groups:
  • Potential
  • Adopter
  • Change Agent
  • Disruptor

• Intelligent systems:
  • Potential goes from coarse-grained discrete system to (mostly) continuous
  • Disruptor & Change Agents become diffuse
    • Enables selective adoption/disruption
    • Incremental adoption
Event/Data proliferation require intelligence

• Transition to when people can do it themselves vs. an expert
  • IOT often relies on a motivated “installer/admin”

• Anticipate problems:
  • Anticipate problems (day light savings time, I am away, vacation lighting)

• Generate structured events from unstructured data
  • # packages at front door
  • # people in a room

• Adaptive Insight
  • cleaners are there - learn, when done.
  • Find second level patterns.
Non-traditional data sources

• Network Join event
• Finger print broadcast (identity)
• Structured events from video streams
• Calendar + geo data
  • When/Where you are going and likely destinations
• Uber / AirBnb (arrival/departure)
• Facebook, Twitter
• Cars
Second generation intelligence

• Emergence of situational intelligence
  • Voice Domains

• Aiding in transition from early adopter to mainstream by introducing concepts naturally,
  • changing when the effort has to be done
  • everyone doesn’t have to become a programmer
  • everyone doesn’t have to become a debugger

• For network systems functionality growing exponentially with devices and data due to interconnects
  • Leading to scalable user interfaces
    • Chatbots
    • Voice
Second-Generation Scenarios

• Security
  • Enable responders
    • Collaborative crowd-sourcing (e.g. license plates)
  • Enable compliance
  • Enable effective escalation

• Home Insurance
  • Better leak/fire prevention

• Anticipate problems
  • Daylight savings
    • Figure out a device that didn’t update ... pro-active
  • Conflicts that occur when vacation mode
  • I am away

• Identify patterns
  • Cleaners are there
  • Send message when done
Challenges with proliferation of connected/automated devices

- Amityville-lighting
- Privacy
- Data brokers
- Have to “see” all the events – (like when security system arms)
  - Simple triggered.
  - Put User in the middle
  - Presumption know all the use cases
  - Blocks second level behaviors.
The Transition

IOT Intelligent Systems today: “Ad Hoc Growth”

Open connected platform tomorrow*: “Grid System”
Collaborative Intelligent Systems

- Enable the system to work together towards goals
  - Evolve objectives
  - Avoid system being

- Collaboratively Sense and Response to Change
  - Identify opportunities

- Persist Data
  - Summarize

- Adapt to meet new challenges

- System starts with a set of expected rules/desired desired response
  - Chooses/Adapts most appropriate response
• Entities / Resources / Capabilities / (simple) Relationships
  • OCF and other relevant standards bodies are making progress
• Processes / Environment / Responses / Restrictions
  • Internalized in most/all real-world implementations
• New Primitives
  • Intent
  • Expectation
  • Promise
• New ideas to IOT system collaboration
  • On-going Calibration
  • Automated governance
  • Adaptive validation
Evolution is not easy or natural

• Early success with single systems
  • With a simple environment or simple use cases can minimize compromise
  • Distributed – Isolated – independent enables many simple use cases
  • Not a natural collaboration model for many commercial systems

• Interplay of Multiple adaptive systems leads to chaos
  • Best case controlled chaos
  • States not clearly defined or homogeneous
  • Fault identification more difficult because of dramatic increase in complexity

• Updating components independently leads to chaos
  • Need orchestration
  • WWST and working with device manufacturers
    • Open ecosystem giving role to orchestrator
    • Involve the a customer (admin) – at odds with
    • What if an orchestrator is compromised?
Problems that weren’t well-solved

• Optimize a cost-function that spans providers
• Satisfy new constraints
• Exhibit new behaviors (building from existing investment)
  • Examples are Alexa-Domain integrations
• Make trade-offs in favor of user/domain-centric goals
  • Arm/Disarm
  • Switching “scenes”, variable dimming
• Overcome adversity – Unfolding circumstance
  • Hub goes offline
  • Power goes out
  • Differing levels of connectivity
Opportunities

• Team-Like organization
  • Coordination
  • Knowledge transfer
  • Roles

• Don’t export System negotiation to the customer
  • Should be self-evident but all current cloud-to-cloud connections do this today
  • We can do better than the current seams in identity provider experience (as one shared experience)

• Standardize interactions
  • Improve existing system with new:
    • Classification
    • Constraints
    • Evolved Actions
  • Extend system with new
    • Events/entities
    • States/Action

• Right Guard Rails
• Open – enables incrementalism
Intelligent Systems Powers the Flywheel of IOT

1. Devices
2. Data
3. Use Cases
4. New Events/Data
5. Greater Engagement
Thank You