Bark: *Default-Off* Networking and Access Control for the IoT

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The IoT is everywhere

So are the attacks...

1. Devices easily compromised

   Mirai botnet

   - Targets IP cameras, DVRs, routers, printers
   - 100,000 IPs and 1.2Tb/s
   - Traffic to port 53 (DNS)

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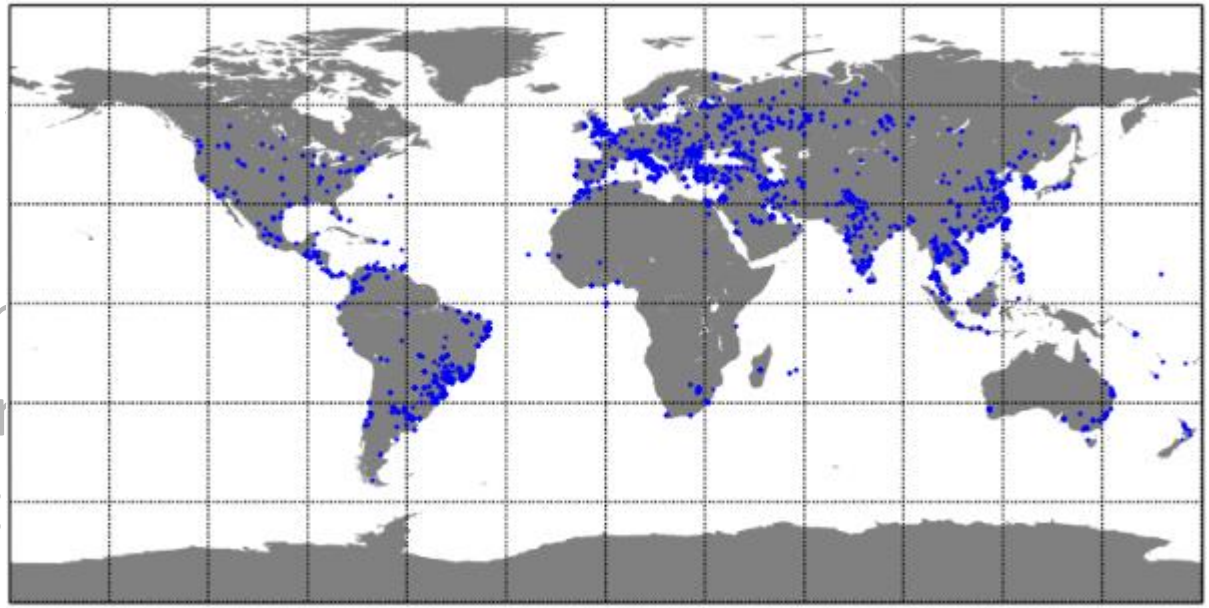

Hajime worm

- Targets devices with open telnet port
- Again, default usernames and passwords

Image: https://www.symantec.com/connect/blogs/hajime-worm-battles-mirai-control-internet-things

So are the attacks…

2. Bugs in software

   Dishwasher directory traversal

GET /../../../../../etc/shadow HTTP/1.0

So are the attacks...

3. Ignoring best-security practices
   - No authentication
   - Sending data in the clear
   - Unsecured ad-hoc network

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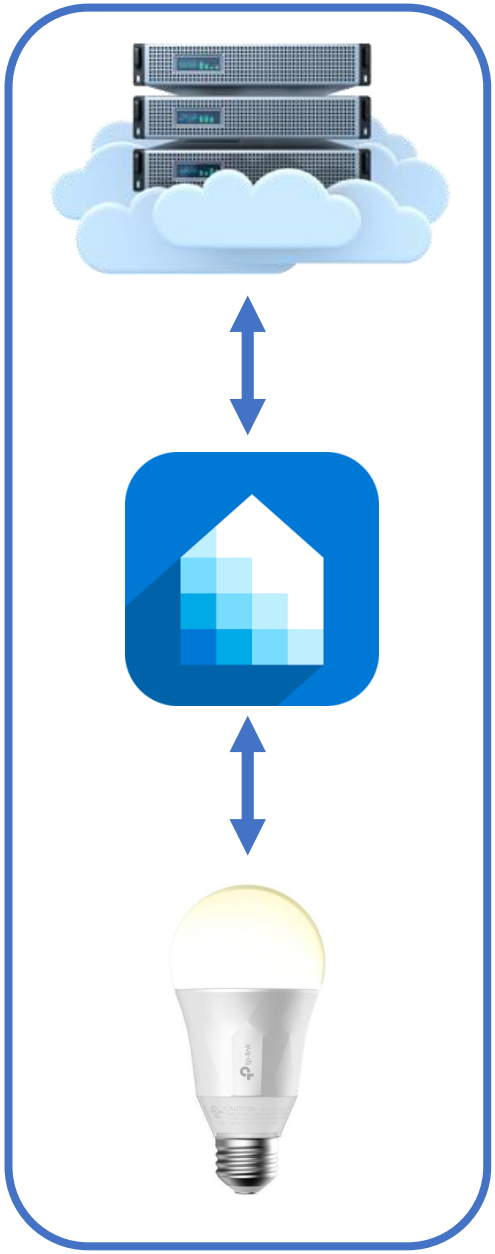
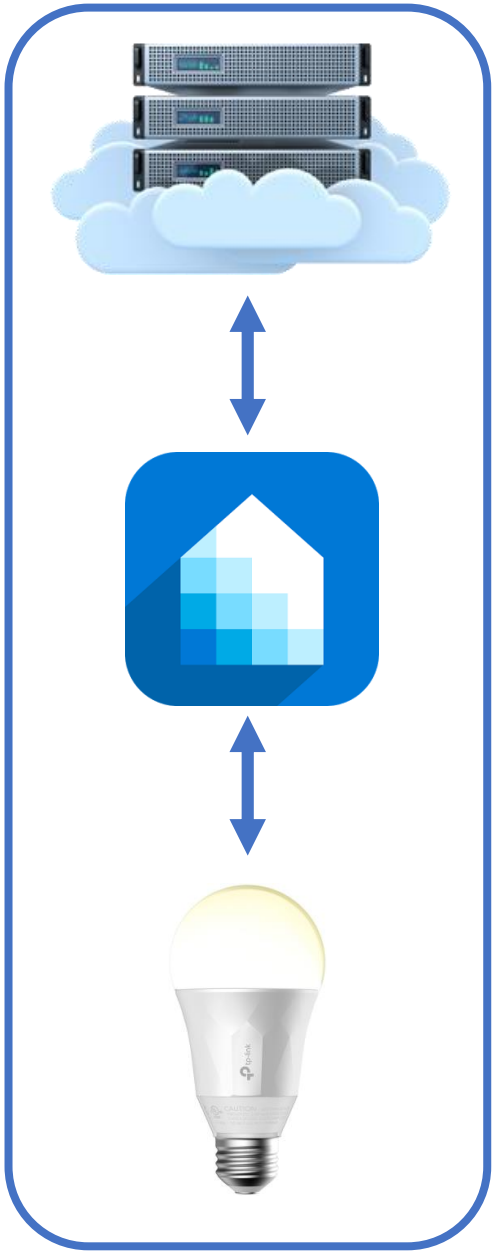
3. Impossible to predict access control needs

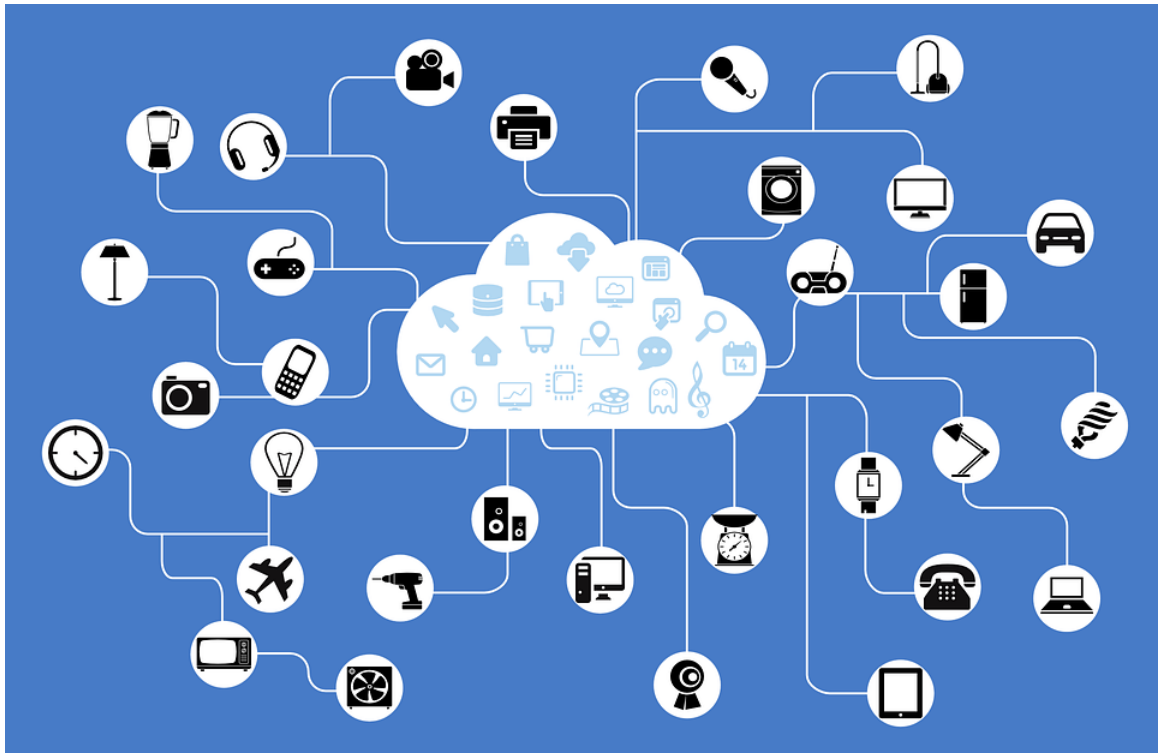


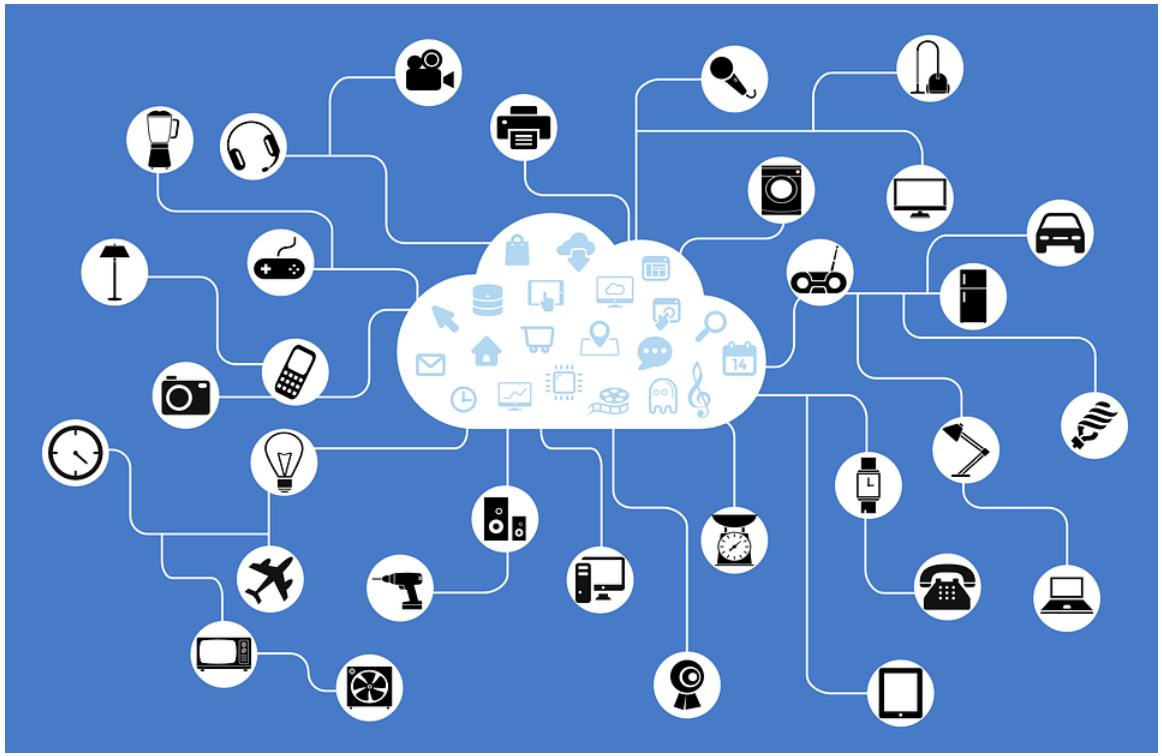
Application Silo



Application Silo

Users, sharing, policies





I don’t know

What is a user?
How is access shared?

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   - IoT devices serve narrow functions and have narrow traffic patterns
   - Disallow everything else

   - Devices cannot DoS DNS servers, send spam
   - Random clients cannot telnet, ssh
   - *Hacked cloud cannot send commands when a user is not home*

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1. *"Default-off"*
2. Policy language to enable *"on"*
   - Expressive *to capture a wide range of applications*
   - Precise *at the granularity of the application layer protocol*
   - Presentable and understandable to humans

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   - *Best effort for each device. (TLS)*

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What — A resource or service of a device named by the protocol
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When	Boolean conditions (e.g., a time constraint, condition such as requiring 2FA)
What	A resource or service of a device named by the protocol (e.g., a HTTP path, DNS on port 53, BLE heart rate service)
How	An action dependent on the “what” (e.g., GET/POST for HTTP, read/write/notify for BLE)

Rules from Types

1. Subject (Who, Where)

   WeMo app on *my smartphone*

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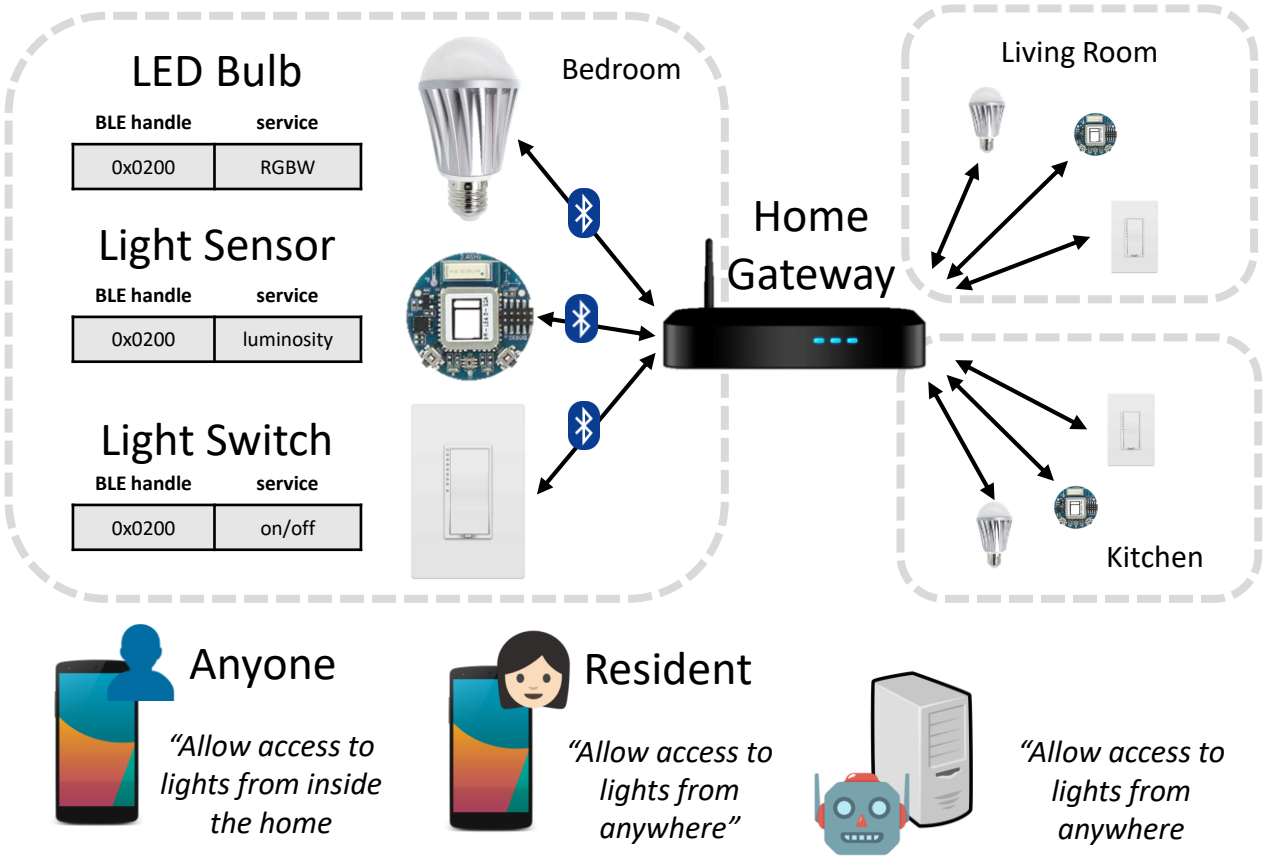
   Allow modification

4. Conditions (When)

   Anytime in the day

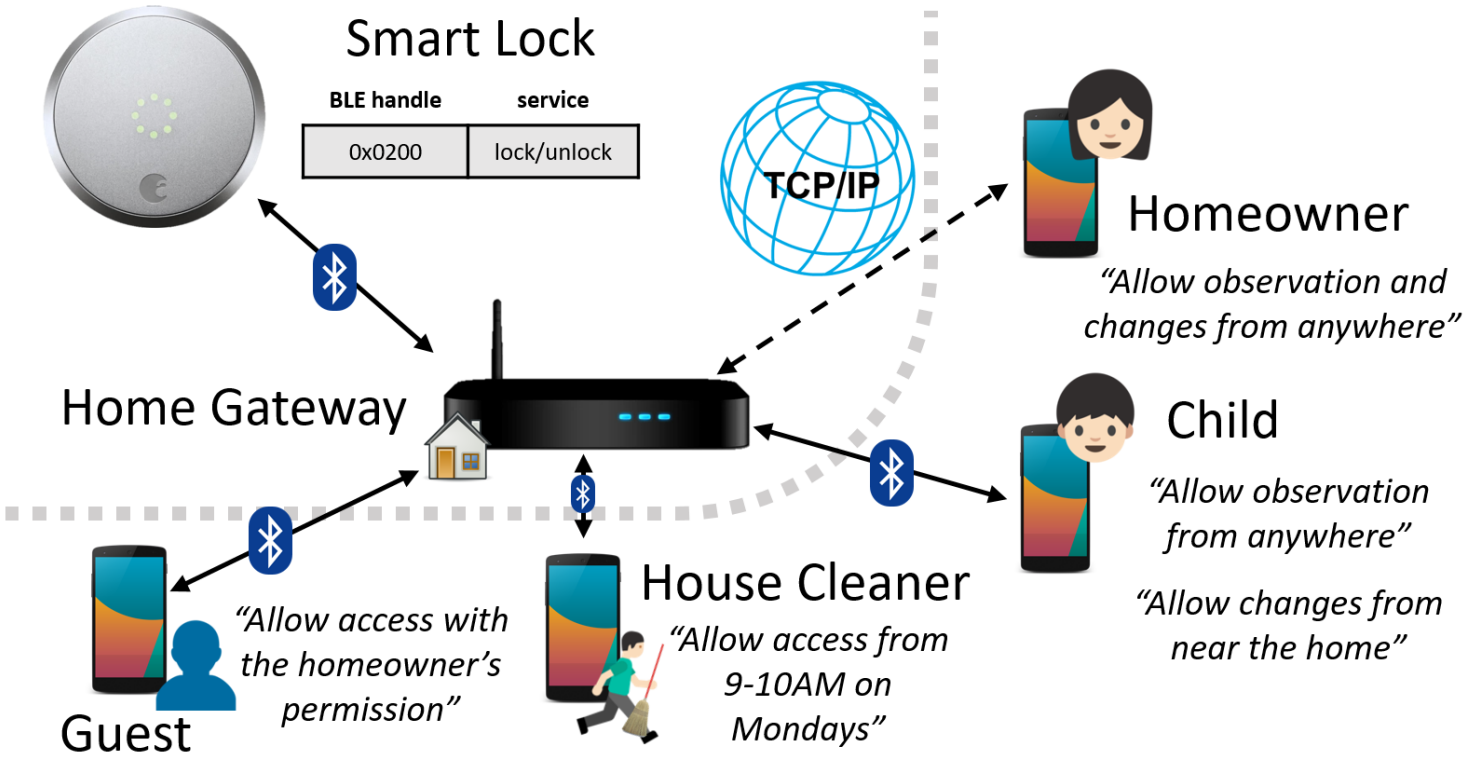

Subject{(WeMo app, James' phone)}
Action{GET/POST}
Who{WeMo app}
Where{James' phone}
How{GET/POST}
Allow WeMo app, at my phone, to modify on/off of WeMo switch, at home, at any time
What{TCP:49153:/upnp/control/basicevent1}
Who{WeMo switch}
Where{Home AP}
When{Cron(* * * * *)}
Object{(TCP:49153:/upnp/..., WeMo switch, Home AP)}
Conditions{Cron(* * * * *)}

This is sufficient for static topologies

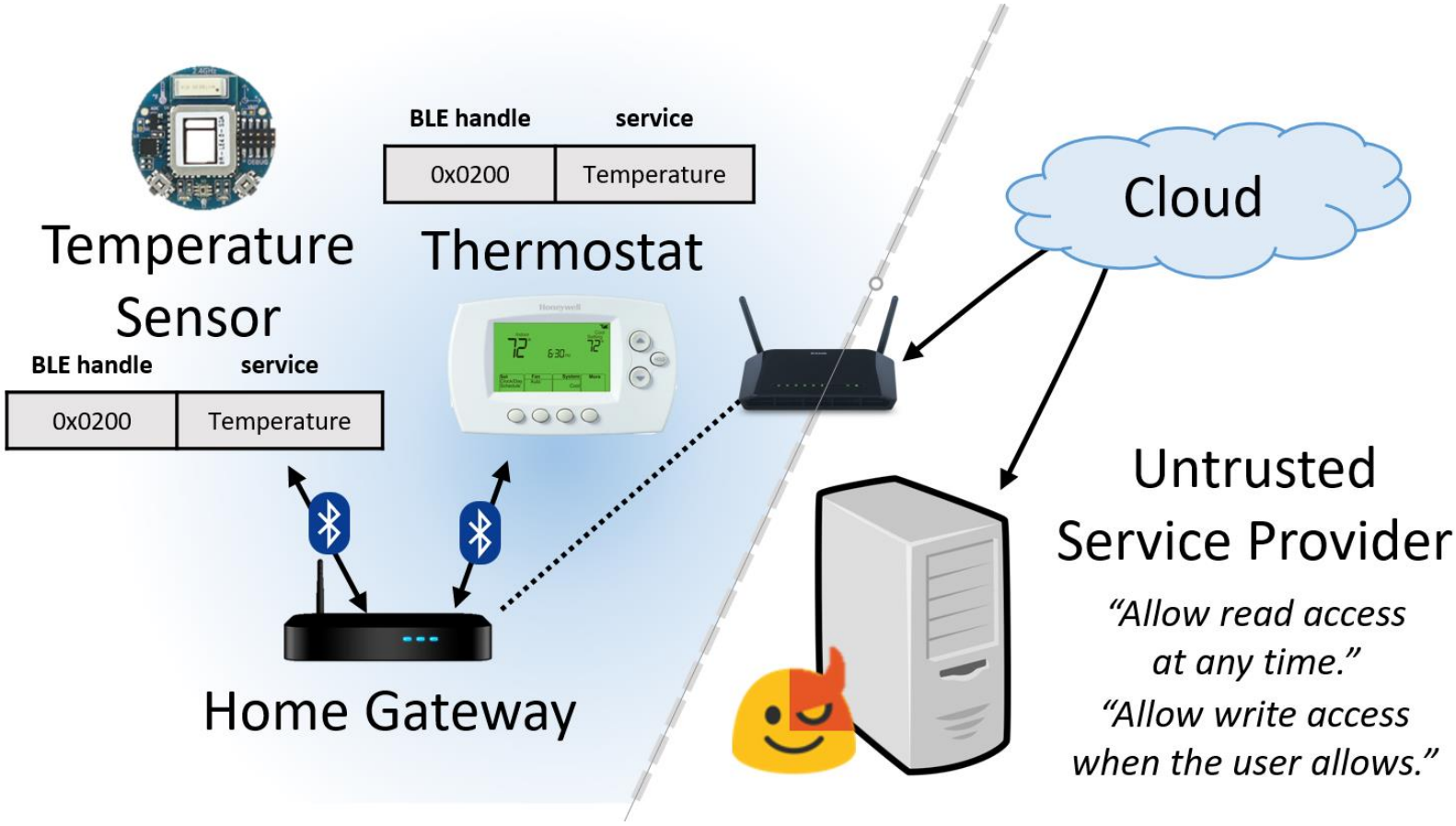


However, …

Sharing a Lock



Distrusting the Cloud



Adding *Conditions (when)*

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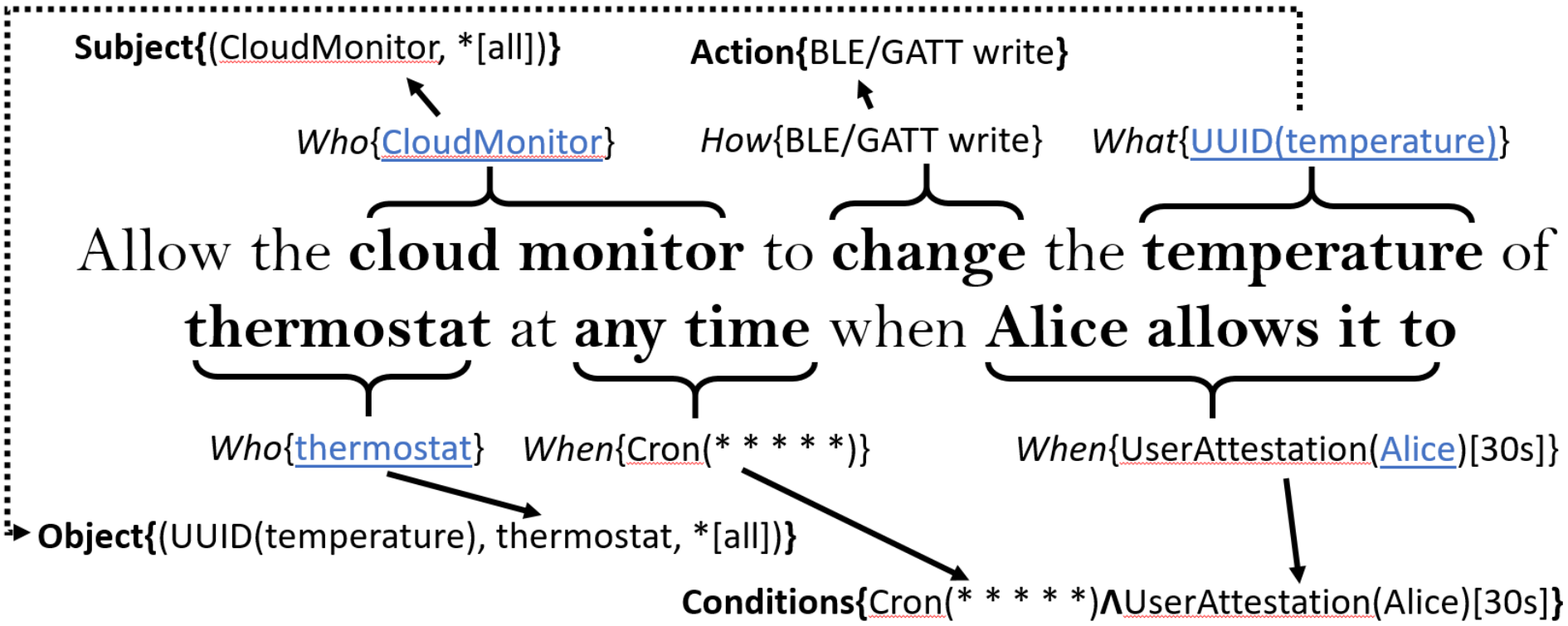
Four familiar schemes

1. Ask the user
2. Ask the owner
3. Authenticate with a password
4. Exclusive access

Example: dealing with a semi-trusted cloud



How well are existing IoT apps supported?

UPnP discovery protocol (SSDP)

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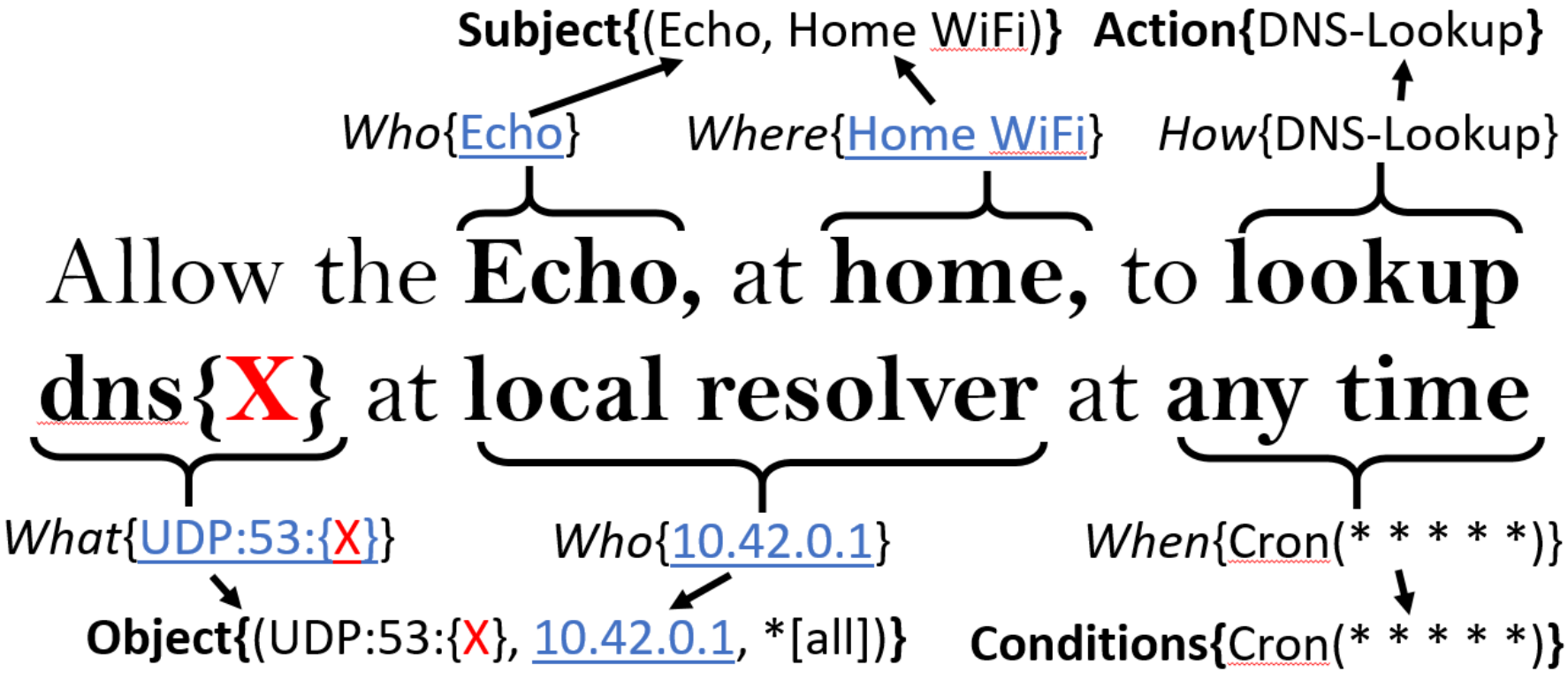
Filtering DNS queries



Wildcards (*) and groups

- Not all of the devices may be known when a rule is specified
- Match patterns in HTTP paths or DNS queries

  (e.g., /event/, *.google.com)*
- Resolve overlaps with (logical-V)

External oracles

1. Automate granting access
2. Express more complex conditions
   - *“only allow the Nest servers to make changes when the Nest app is in the foreground of your smartphone”*
   - *“allow your child to use certain appliances when some adult is present in the home”*

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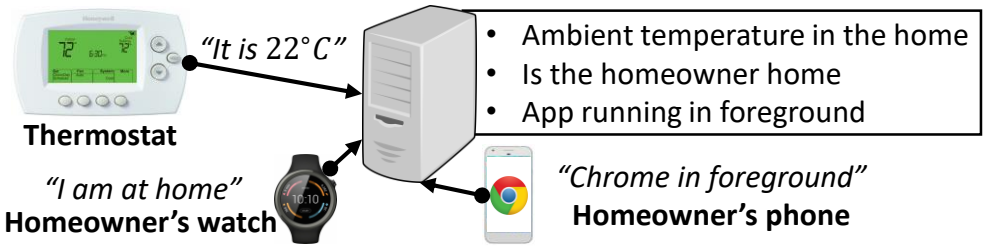
Implemented as server the gateway can query.



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3. Tasks such as authenticating endpoints, setting up secure channels are still the application's and network's responsibility.

Implementation

1. WiFi access point
   - Uses iptables rules to yield certain decisions to a user application

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2. Bluetooth Low Energy (BLE) with **Beetle**
   - Virtualization system for BLE periperals
   - Paper at MobiSys ’16 (Levy, et al)

Code is public, along with Beetle
https://github.com/helena-project/beetle

Thanks and Questions?