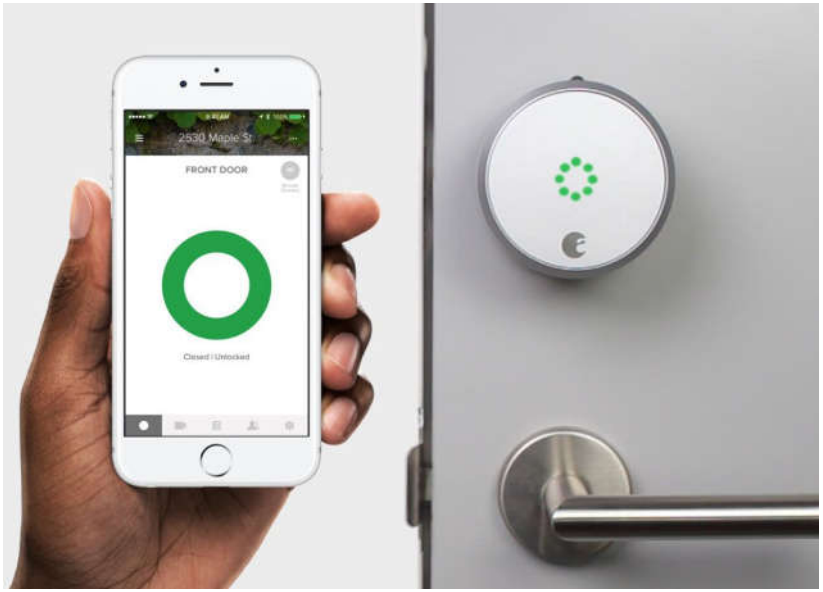
Course Project for CIS427

Design and Prototype Your Smart Lock System

Smart Locks

- Wireless Communication Protocol:
  - WiFi (winner so far), Bluetooth, Zigbee, NFC, …

Wireless Standard	Power	Transmission Range (typical)	Data Rates
Bluetooth	Medium	1 to 100 m	1 to 3 Mbps
Bluetooth LE	Lower	>100 m	125 kbps to 2 Mbps
LoRaWAN	Low	10 km	0.3 to 50 kbps
NB-IoT	Low	<35 km	20 kbps to 5 Mbps
NFC	Low	<10 cm	106 to 424 kbps
Sigfox	Low	3 to 50 km	100 to 600 bps
6LoWPAN	Low	100 m	0 to 250 kbps
802.11/Wi-Fi	Medium	100 m to several km (with boosters)	10 to 100+ Mbps
802.15.4/Zigbee	Low	10 to 100 m	20 to 250 kbps
Z-Wave	Low	15 to 150 m	9.6 to 40 kbps



Let’s see what the market likes☺

August Smart Lock Pro (3rd Gen) + Connect Hub - Zwave, HomeKit & Alexa Compatible - Silver

Visit the August Home Store

4.5 ★★★★½ 9,743 ratings

Amazon's Choice for "smart lock"

Best Seller

List Price: $229.99

Price: $129.99 prime & FREE Returns

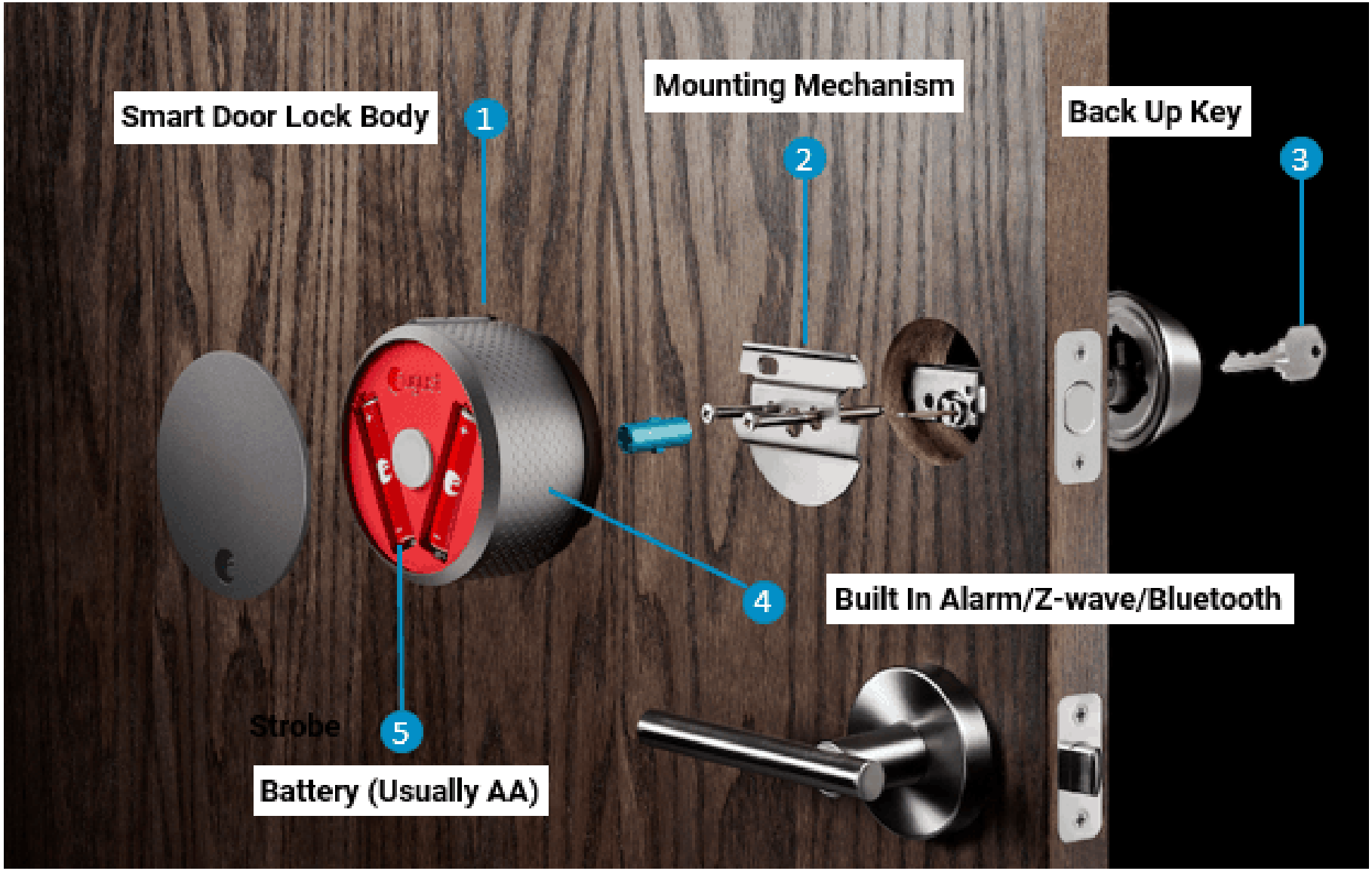
or 5 monthly payments of $26.00

You Save: $100.00 (43%)

Get $70 off instantly: Pay $59.99 $129.99 upon approval for the Amazon Prime Rewards Visa Card. No annual fee.

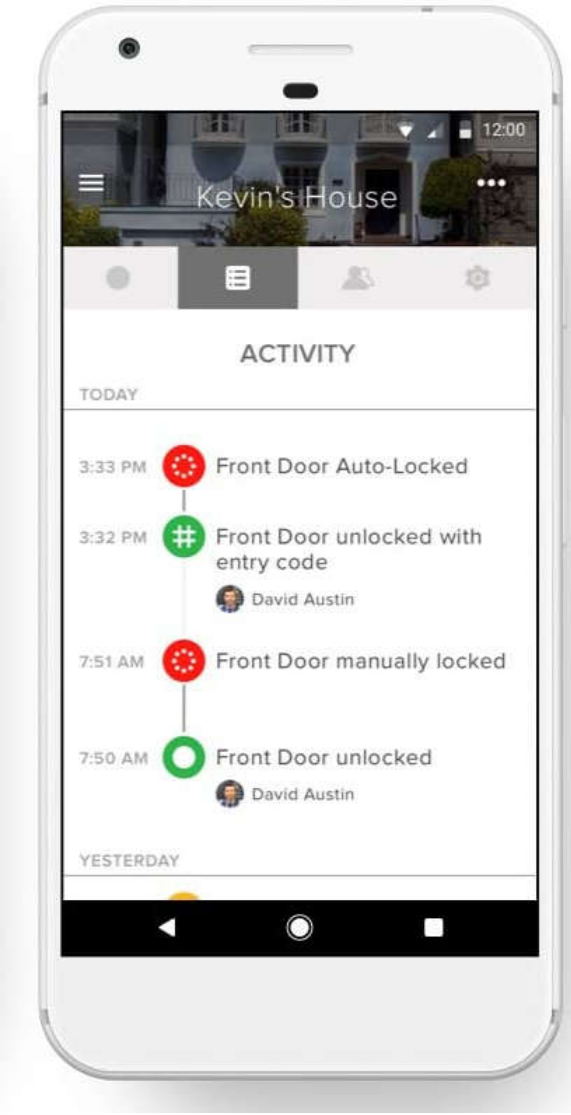
May be available at a lower price from other sellers, potentially without free Prime shipping.

Color Name: **Silver**


Smart Door Lock Body
1
Mounting Mechanism
2
Back Up Key
3
4
Built In Alarm/Z-wave/Bluetooth
Strobe
5
Battery (Usually AA)

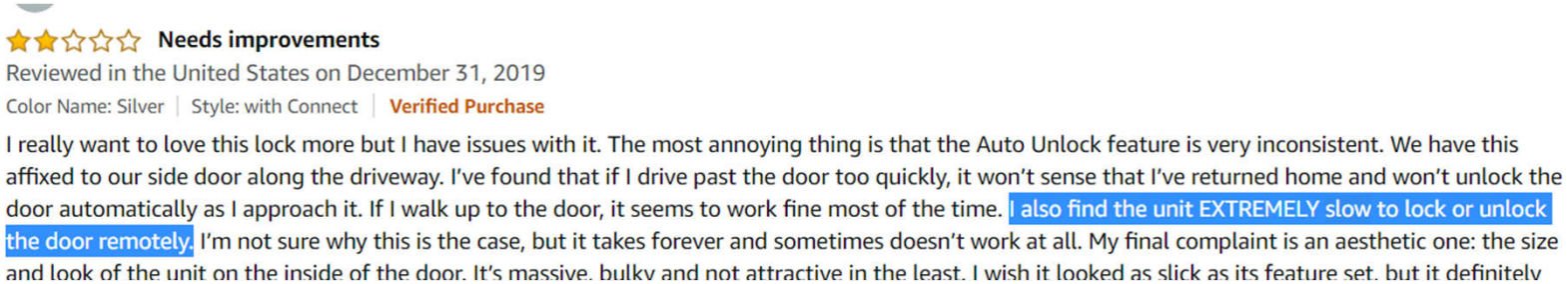
Their Design Features

- Wireless requirements - 2.4GHertz Wi-Fi network (and BLE)
- Work on 4 AA Batteries
- Lock and unlock your door, keyless access all from your phone
- Always know who is coming and going. Track activity



Major Complains

1) latency:



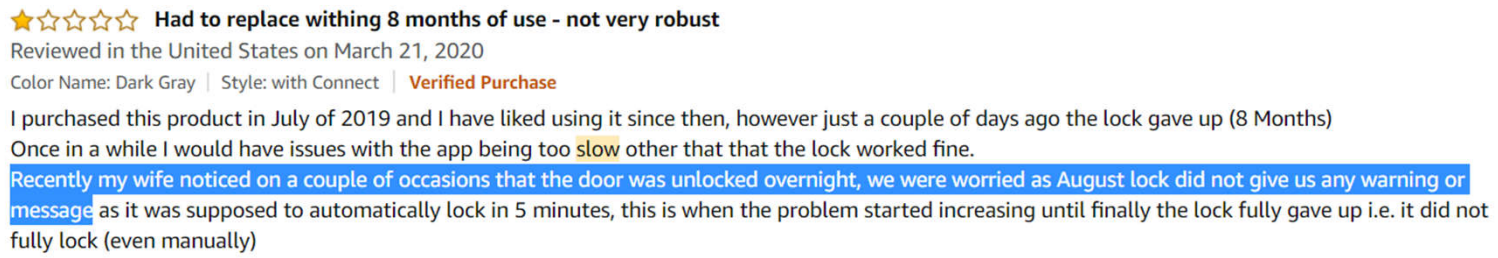
Needs improvements

Reviewed in the United States on December 31, 2019

Color Name: Silver | Style: with Connect | **Verified Purchase**

I really want to love this lock more but I have issues with it. The most annoying thing is that the Auto Unlock feature is very inconsistent. We have this affixed to our side door along the driveway. I've found that if I drive past the door too quickly, it won't sense that I've returned home and won't unlock the door automatically as I approach it. If I walk up to the door, it seems to work fine most of the time. I also find the unit EXTREMELY slow to lock or unlock the door remotely. I'm not sure why this is the case, but it takes forever and sometimes doesn't work at all. My final complaint is an aesthetic one: the size and look of the unit on the inside of the door. It's massive, bulky and not attractive in the least. I wish it looked as slick as its feature set, but it definitely

2) Reliability:



Had to replace withing 8 months of use - not very robust

Reviewed in the United States on March 21, 2020

Color Name: Dark Gray | Style: with Connect | **Verified Purchase**

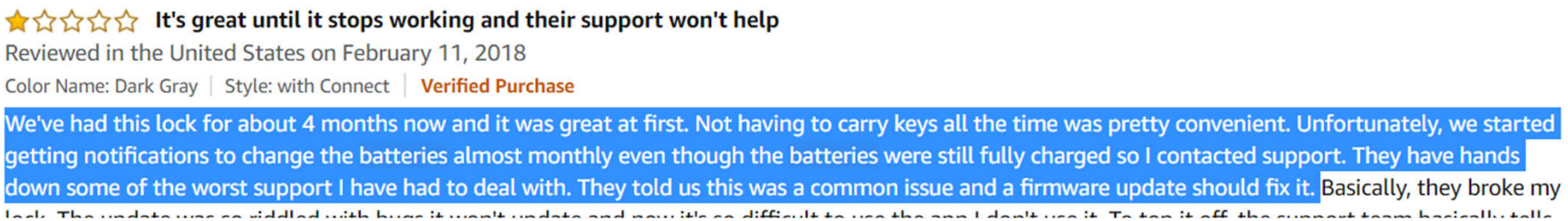
I purchased this product in July of 2019 and I have liked using it since then, however just a couple of days ago the lock gave up (8 Months)
Once in a while I would have issues with the app being too slow other that that the lock worked fine.
Recently my wife noticed on a couple of occasions that the door was unlocked overnight, we were worried as August lock did not give us any warning or message as it was supposed to automatically lock in 5 minutes, this is when the problem started increasing until finally the lock fully gave up i.e. it did not fully lock (even manually)

3) Consistency:

Then, a few weeks ago, I got a notification from the app that the keypad batteries were "low." I figured I would change them in a couple of hours, when I got home. About 5 minutes later, I got a call from the exterminator to tell me the lock hadn't locked behind him when he left. It looked fine in the app, but it didn't lock behind me when I got home, either.

Feedbacks:

4) Energy Efficiency:



It's great until it stops working and their support won't help

Reviewed in the United States on February 11, 2018

Color Name: Dark Gray | Style: with Connect | Verified Purchase

We've had this lock for about 4 months now and it was great at first. Not having to carry keys all the time was pretty convenient. Unfortunately, we started getting notifications to change the batteries almost monthly even though the batteries were still fully charged so I contacted support. They have hands down some of the worst support I have had to deal with. They told us this was a common issue and a firmware update should fix it. Basically, they broke my

update 12/29/2017

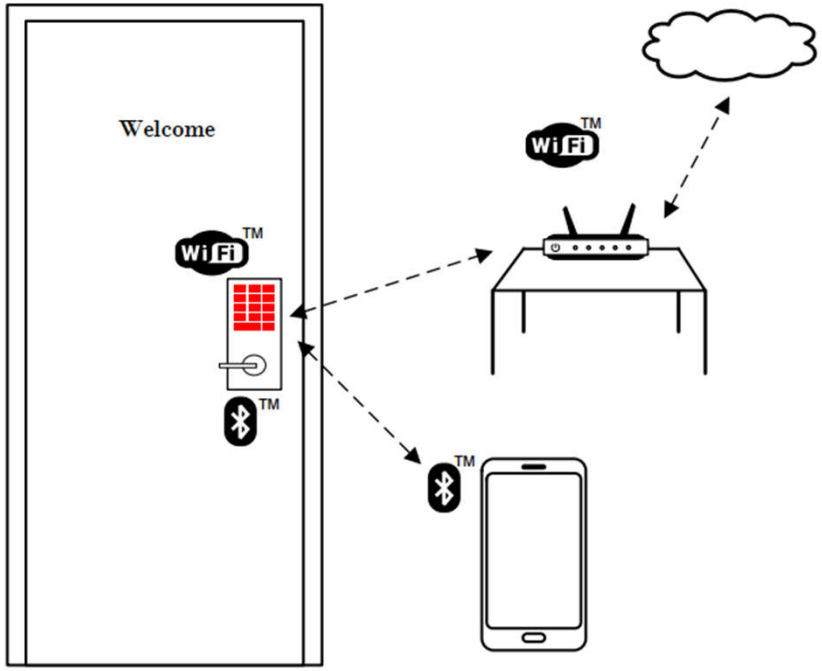
6) After a month of use I got a message to replace lock battery. From what I read online the battery should last approximately 6 months, For a third generation of product line this version is turning out to be a big disappointment.

System Design

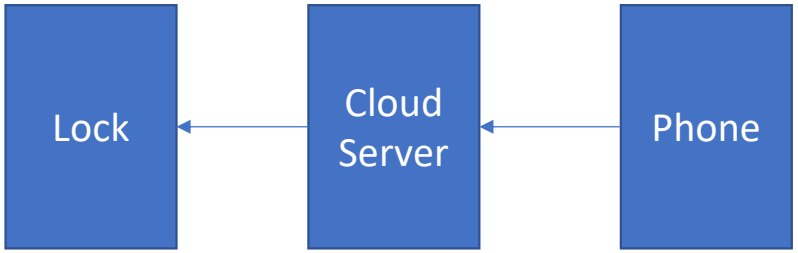
Two Communication Channels: WiFi & BLE

Two Operation Modes:

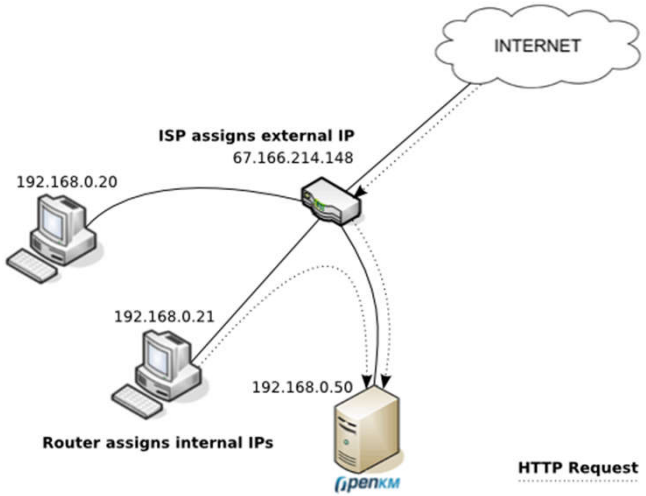
1) Phone communicates with cloud, cloud controls lock
2) Phone controls lock directly via BLE



How does it work?



- Why we need both BLE and WiFi? --- WiFi can be slow…
- Why WiFi can be slow?
  - https://www.hackster.io/hackershack/smartphone-connected-home-door-lock-69944f
  - https://www.youtube.com/watch?v=bAcK80fm1_0
  - Js code: https://github.com/HackerShackOfficial/Smartphone-Doorlock/blob/master/doorlock.js
- Why we need a cloud server?
- Impact on Performance:
  - Latency, energy, Reliability
  - Is it just a matter of tradeoff?

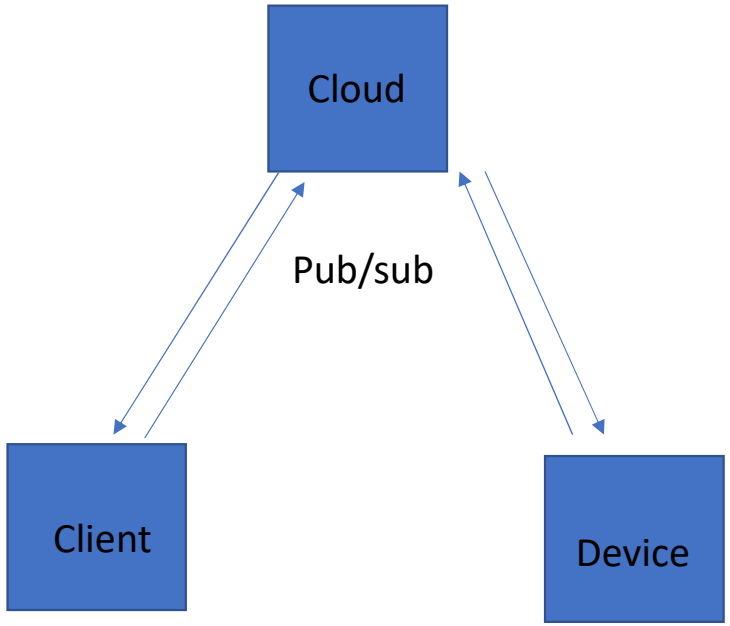


Web of Things Integration Patterns

- Cloud Integration Pattern
- Direct integration Pattern
- Gateway Integration Pattern

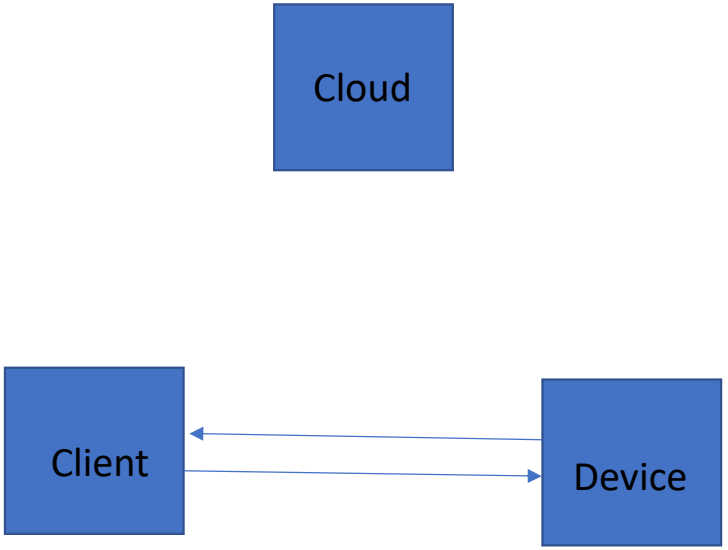
WoT Cloud Integration Pattern

- Some device have access to the cloud.
- Problem: sometimes the client and the device are close, but still need to go through a remote cloud.



WoT Direct Integration Pattern

- Some device have full internet access.

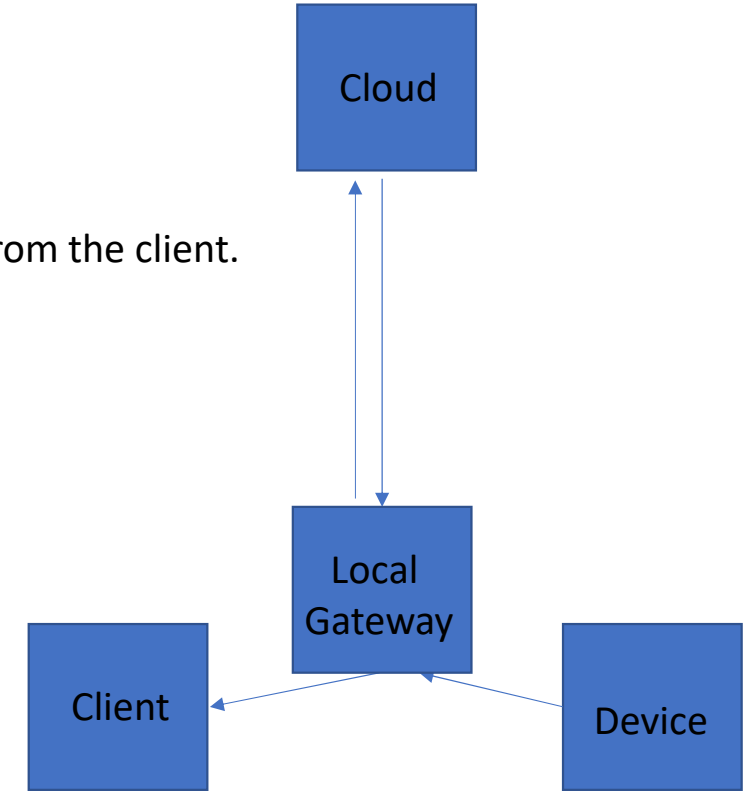


- Typical use case: The device communicates with low latency to a local device like a phone.
- Example: Use a phone to communicate via WiFi (with WiFi router) to an HTTP server on a device. Use web sockets for publish/subscribe, e.g., phone listens for doorbell events.

WoT Gateway Integration Pattern

- Gateway Integration Pattern.

The interaction between the gateway and the device is hidden from the client.

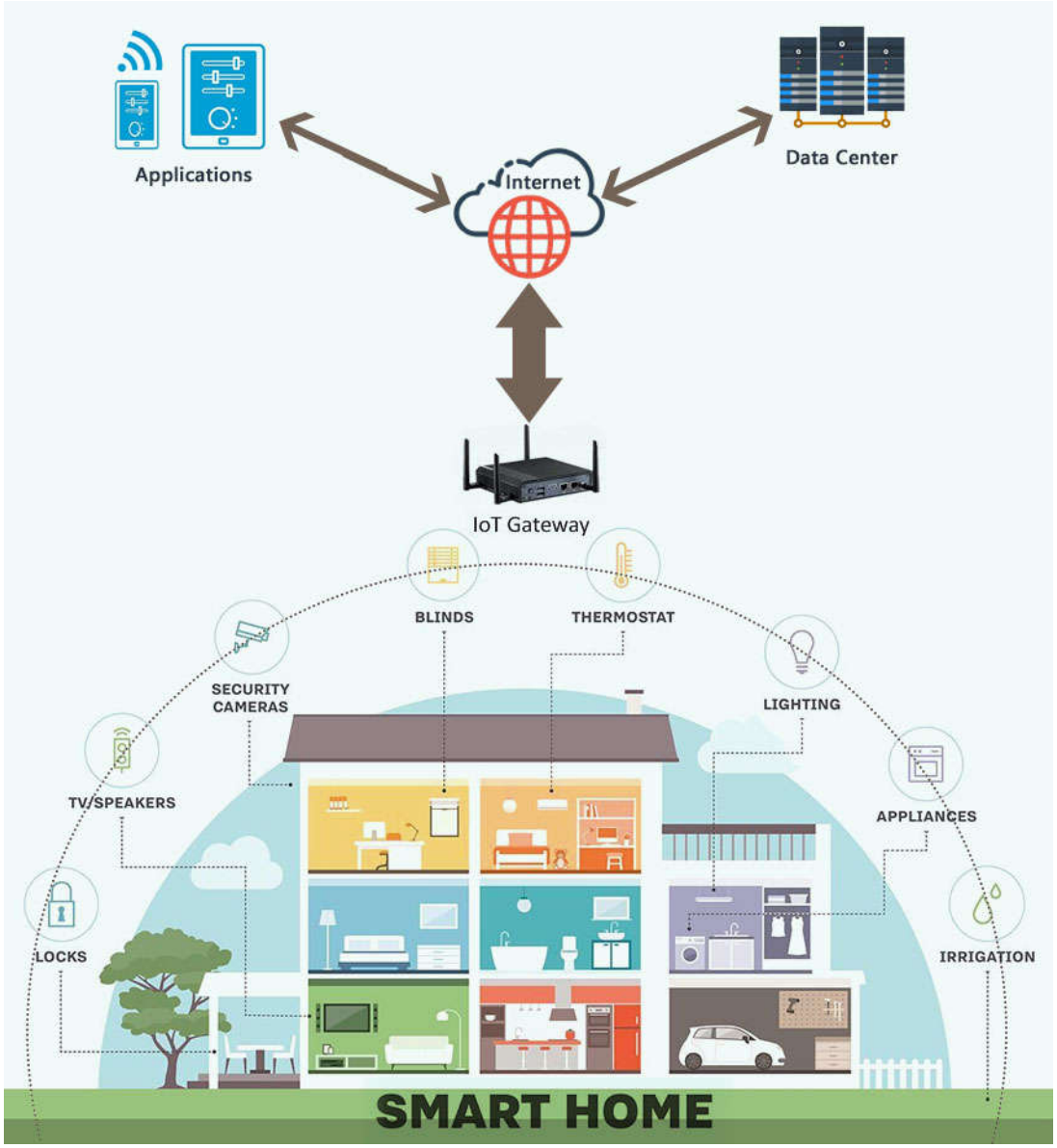


Benefit:

1) predictable and consistent latency
2) no need to maintain connection in local area network
3) prevent privacy issues.

A typical smart home architecture:

1. Smart devices
2. Gateway
3. Applications

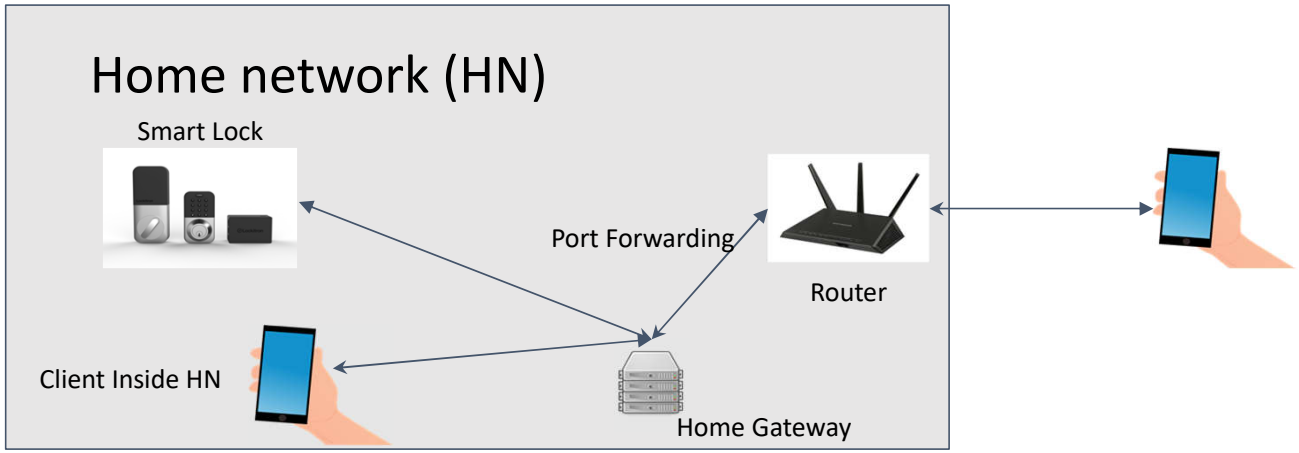


Checkpoint 4: design your own smart lock

General Design/Implementation Procedures:

- System modelling (fixed)
- Functional requirements (fixed)
- Non-functional requirements
- Security concerns (can be ignored now)
- System/Communication Interface Design
- Implementation Plan (who will do what)

System Model



Assumptions:

1. No connection from outside phone to smart lock
2. All devices inside WiFi home network can communicate with each other.
3. A outside device can access the server inside the home wifi network. (how? ddwrt)

Functions of the Lock

1. Register itself to the gateway and send heartbeats and operation logs.

2. Lock & unlock if given the correct password (permanent or temporary).

3. Activate or deactivate the temporary password (once used to unlock the door, the temporary password should be disabled automatically).

4. Send notifications if someone breaks the lock.

5. Return operation results and error messages.

security Issues:

https://published-prd.lanyonevents.com/published/rsaus17/sessionsFiles/4479/SBX2-R2-All-Your-Locks-are-BLEong-to-US.pdf

>>> Vulnerable Devices

* Plain Text Password
  - Quicklock Doorlock & Padlock v1.5
  - iBluLock Padlock v1.9
  - Plantraco Phantomlock v1.6
* Replay Attack
  - Ceomate Bluetooth Smart Doorlock v2.0.1
  - Elecycle EL797 & EL797G Smart Padlock v1.8
  - Vians Bluetooth Smart Doorlock v1.1.1
  - Lagute Sciener Smart Doorlock v3.3.0

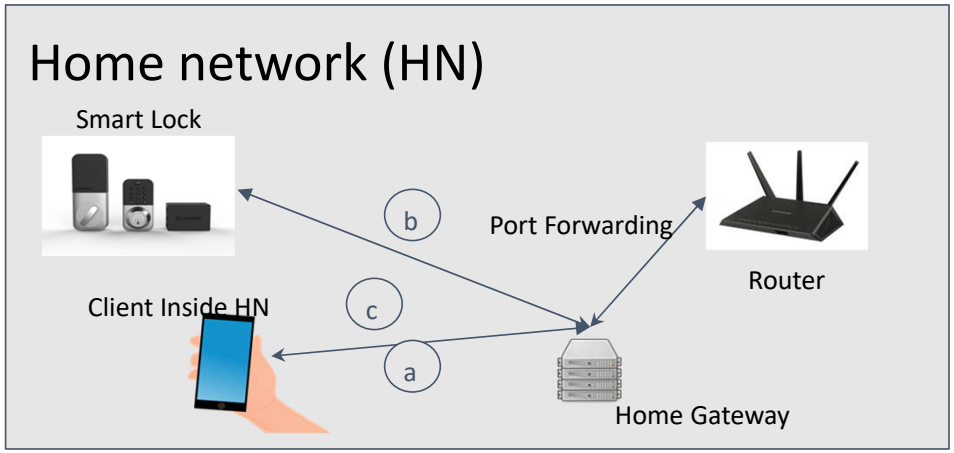


NFR Example

Function 1: lock & unlock upon receiving the correct password.

- Communication flow:
  a. Client sends the request to the home gateway;
  b. Home gateway controls the smart lock
  c. Home gateway sends operation result back to the client.

- Non-functional requirement:
  - Low Latency: 30ms
  - High Reliability: confirmable
  - Cost efficiency: avoid keep-alive messages

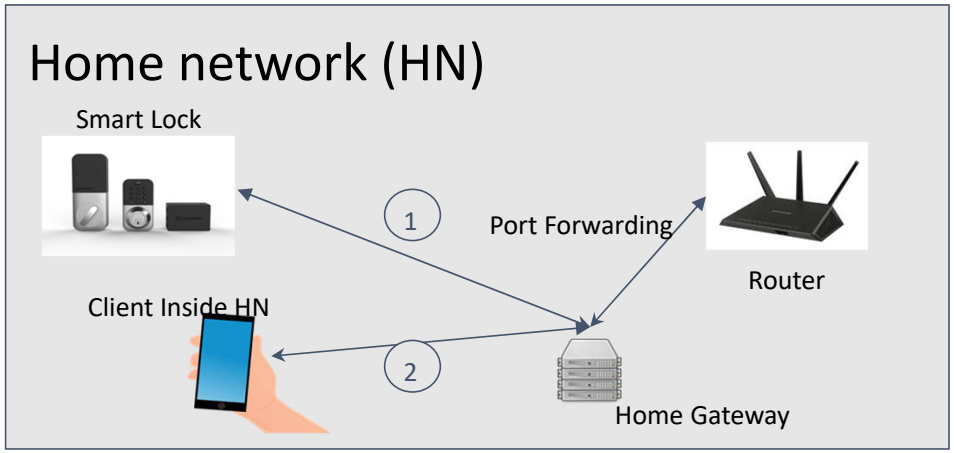


NFR Example

Function 2: Heartbeat

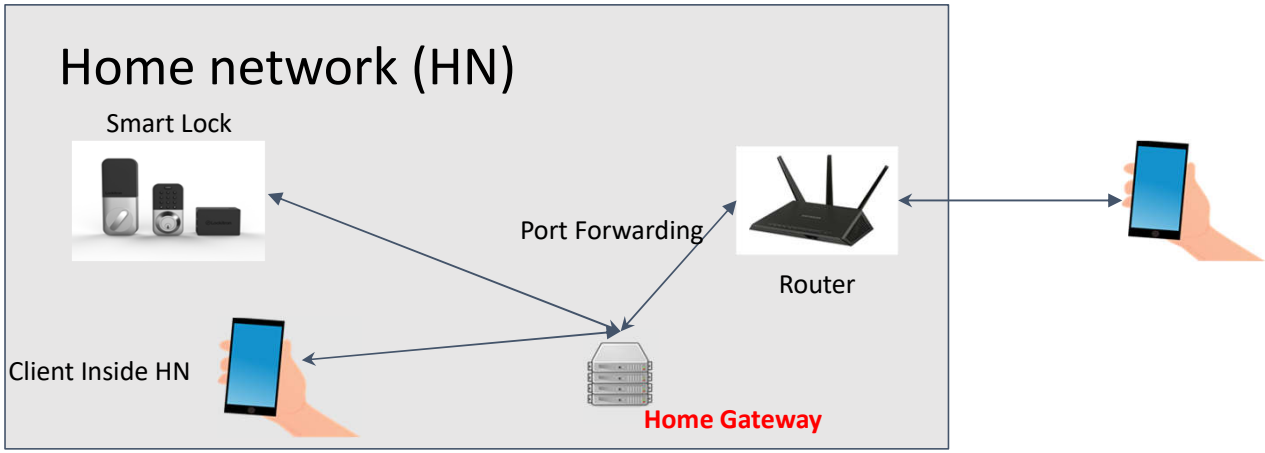
- Communication Flow:
  - Smart locks send periodical heartbeats to home gateway
  - a client can send request to check heartbeats
  - a client will receive notifications when the the gateway doesn't receive normal heartbeat (miss *n* HBs in a row) from the smart locks.

- Non-functional requirement:
  - Send HB every 5 minutes;
  - Reliability: *m*% (how m impact n?)



System Design Example

1. gateway:
    a. HTTP Server to mobile clients:
    b. coAP client: lock/unlock
    c. CoAP server: discover IoT resources/collect heartbeat

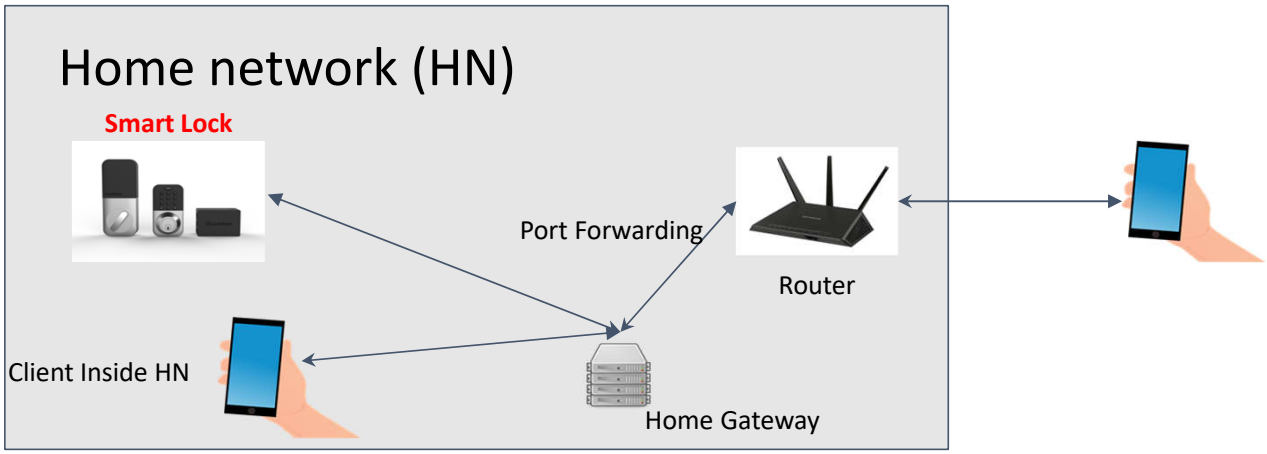


System Design Example

2. Smart Lock:

a. CoAP Server for lock/unlock

b. coAP Client for heartbeats



Interface Design Example

1. HTTP Server on Home Gateway **This is not secure!!!**
   a. Restful Interface for mobile clients:
      i. Get http://homeIP/front_door_lock/status?password=test
      ii. PUT http://homeIP /front_door_lock/lock?password=test
   b. Response:
      i. Operation result: Json formation (see right figure)

Tips:

1. You can choose to implement necessary parts of your design, not all of them.
2. This is a networking course! Focus on how your communication procedure impacts the system's performance! Keep your report within 3 pages.
3. Divide the workload:
    1. Deliver on time: one video presentation required for CP5.
    2. Everyone has reasonable contribution: individual reports required for CP5.
4. Exploration project. If you are interested in exploring some possibilities, contact the instructor

If not clear, see what others are doing…

August wifi smart lock:

1. https://august.com/pages/how-it-works
2. Video: https://www.youtube.com/watch?v=42znpiPWnl8

https://www.home-assistant.io/integrations/lock.mqtt/

https://github.com/aharshac/smart-lock

https://github.com/maximemoreillon/lock

https://github.com/CESARBR/knot-cloud-websocket

COAP example