IOTSAFE: Enforcing Safety and Security Policy with Real IoT Physical Interaction Discovery

Ding, Wenbo, Hongxin Hu, and Long Cheng. "IOTSAFE: Enforcing Safety and Security Policy with Real IoT Physical Interaction Discovery." (2021).

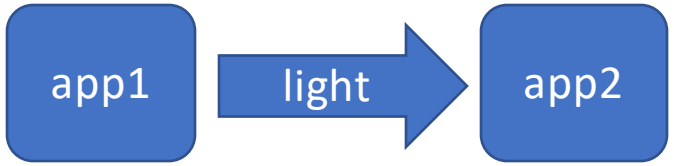
Smart home - safety and security problems

Problems:

- device firmware flaws
- protocol flaws
- information leakage
- malicious applications
- side channel attacks
- …

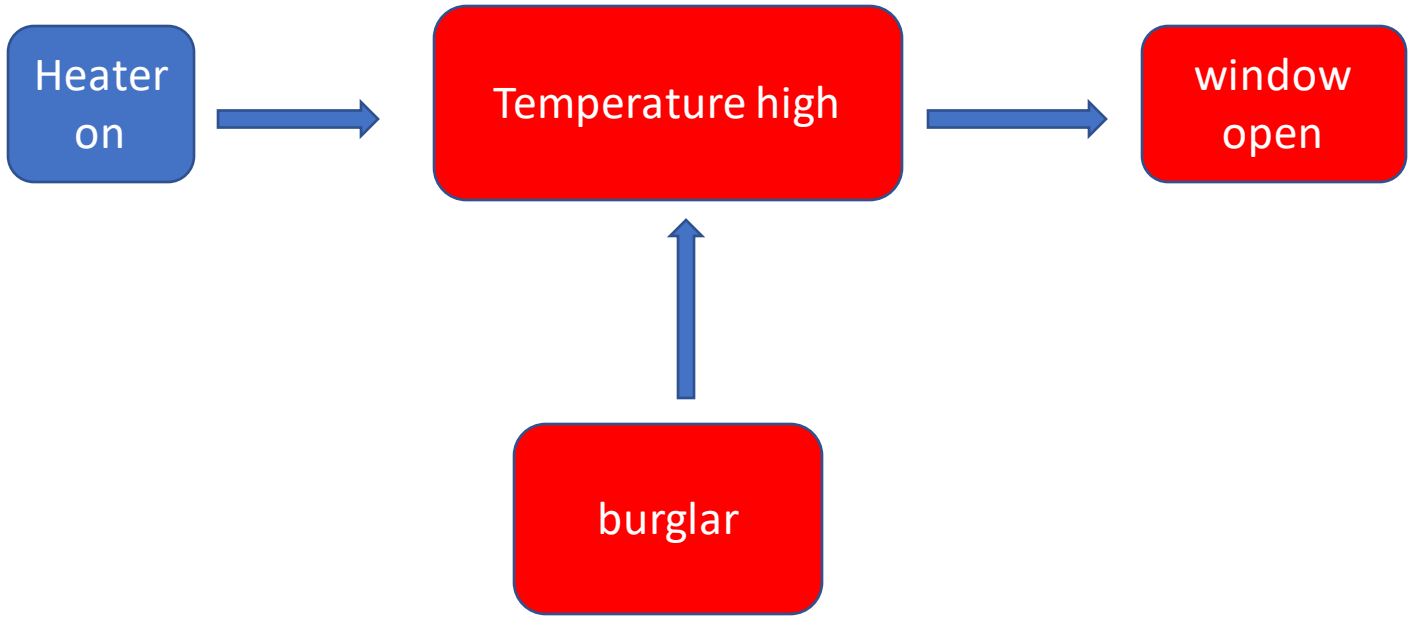
Interactions of IoT apps/devices

- *Cyberspace interactions :* cross-app interactions where multiple apps subscribe/operate the same device.
  - e.g., app1 turns on the light after sunset, app2 unlocks the door when the same light is turned on.



- *Physical interactions:* physical impacts enable apps that subscribe *different* devices to externally interact with each other through shared physical environment channels

Physical Interactions - risk



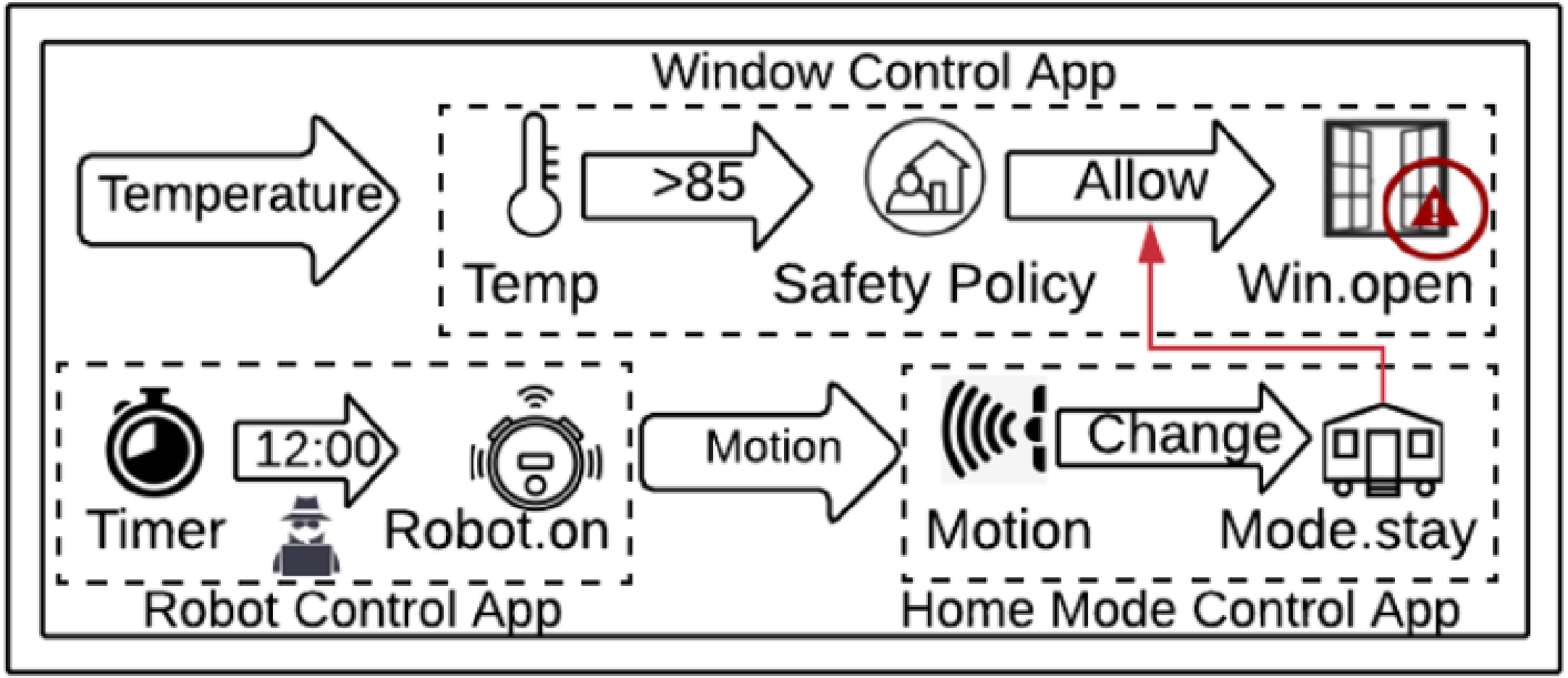
Dynamic physical interaction control with risky situation prediction in multi-app IoT environments.

Challenges

1. Text mining of app descriptions cannot be applied to detect real-time physical interactions in **dynamic physical interaction** control.
   side effects: spatial location, device influence range, environment conditions

2. Temporal aspect of physical interactions:
   1. Immediately
   2. Slowly but continuously

IoTSafe


Window Control App
Temperature
>85
Allow
Temp
Safety Policy
Win.open
12:00
Motion
Change
Timer
Robot.on
Motion
Mode.stay
Robot Control App
Home Mode Control App

IoTSafe

1. Capture real physical interactions among IoT devices.
2. Predict the risky situations
3. Evaluate the system on SmartThings platform.

IoTSafe - overview

1. App Analysis
2. Real Physical Interactioni Discovery
3. Runtime Prediction
4. Policy Specification and Enforcement

App Analysis

Purpose: analyze control flows in apps

1. Code analysis.
2. Interaction graph generation.

```
1  <name: "Turn on It When Water Detected">
2  def installed()
3  {    subscribe(waterSensor1, "waterSensor",
       waterHandler)
4       info = getdeviceInfo()
5       sendRequest(info)
6       }
7  def waterHandler(evt)
8  {    actions = "switch.on()"
9       resp = sendRequest(evt,actions)
10      if(resp == 1) {switch.on()}
11 }
12 def sendRequest(param)
13 {    def result = true
14      result = httpGet(url, path) {param}
15      return result  //Server Response
16 }
17 def getdeviceInfo()
18 { def deviceInfo = []
19      settings.waterSensor1.each{
20        deviceInfo << it.displayName
21          deviceInfo << it.deviceId}
22      return deviceInfo
23 }
```

Listing 1: An example of app instrumentation.

Real Physical Interaction Discovery

Purpose: explore a new dynamic testing approach to identify real physical interactions among IoT devices.

1. Testing case generation for grouped devices.

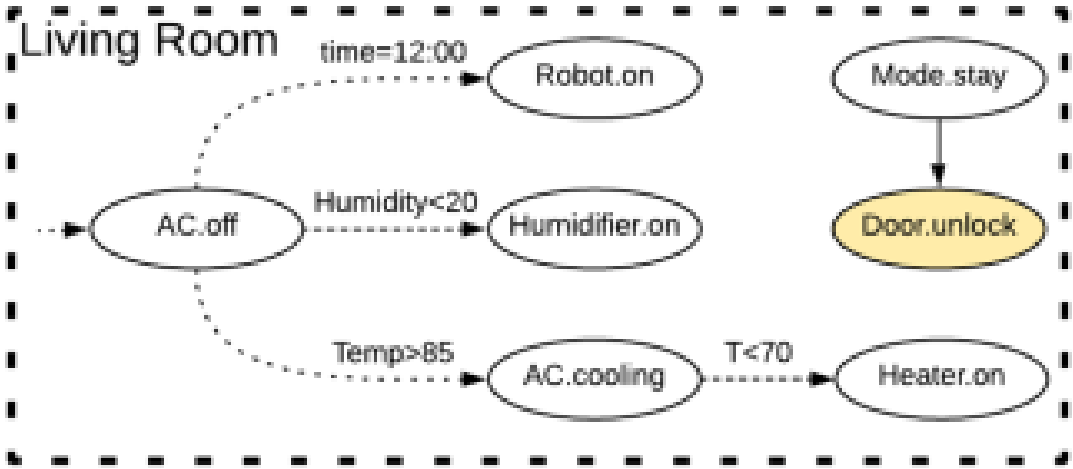
   (humidifier.on, AC.off, heater.off, robot.on)

   (humidifier.off, AC.off, heater.off, robot.on)

2. Dynamic testing

   Multiple method to reduce overhead:

   - Greedy algorithm
   - Single room parallel testing



Runtime Prediction

1. Offline Physical Modeling – physical channels - temperature, humidity, smoke, and water level
2. Runtime policy violation prediction.
3. Initialization for new device

Real Physical Interaction Discovery

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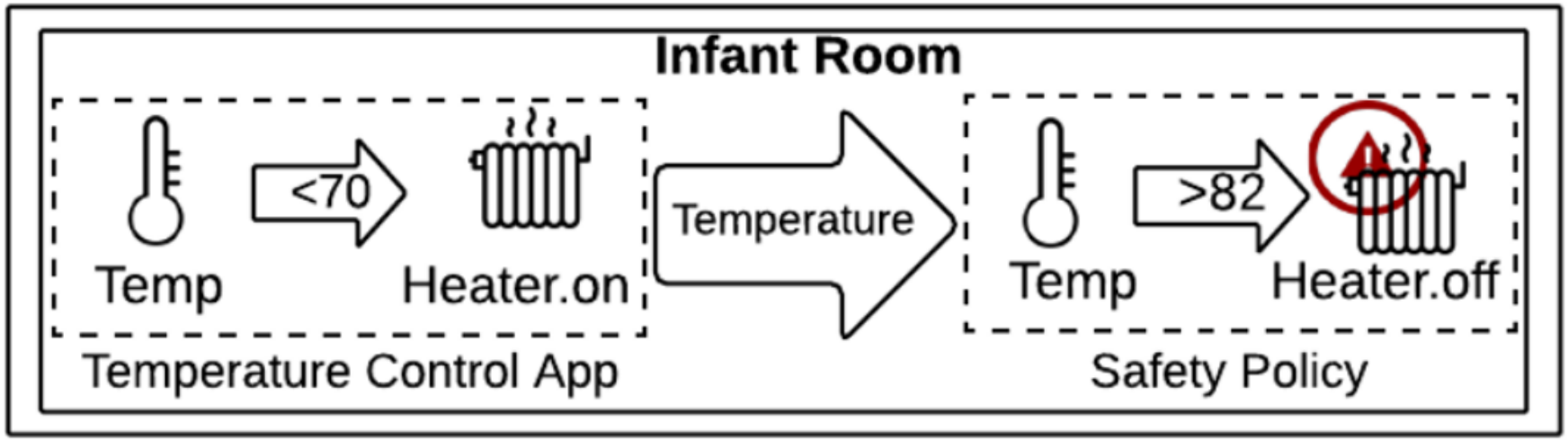
Safety and Security Policy Specification



Turning off the heater and send a warning when the temperature is above 85F.

Evaluation – testbed settings

Platform: Samsung SmartThings

Smart Apps: studied 45 official SmartThings applications, 21 was deployed

IoTSafe:

1. Static analysis tool
2. Policy enforcement server
3. Three special SmartThings app - data collector, runtime monitor, and policy manager.

User:

•Choose testing/restricted devices

1. Set user policies

Evaluation – testbed settings

User:

1. Choose testing/restricted devices

2. Set user policies

Home mode controls temperature device
Temperature sensor controls heaters, AC, fan, and windows
Home mode controls lights and locks
Light Sensor controls Window shades
Motion Sensor controls Lights
Light Sensor controls lights