[SmartHome+]
Requirements Evaluation and Risk Analysis
16/7/2020

Team 21

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Content

Task1 Identifying and finding inconsistencies

Inspection Defect And Inconsistency List

Project:SmartHome+

Defect #	Location	Defect/inconsistency type	Classification	Author	Status	Date corrected
1	When the smoke alarm or water leak alarm is activated, the user will not only hear the alarm sound but also receive a reminder from the remote device. The SmartHome+ will always turn on the water purification equipment once people open taps at home.	Omission	Minor	Jiuxiang Chen	Open	2020.7.8
2	The SmartHome+ can record the normal pets' activity track and store the data. Once the pet's track is abnormal according to the SmartHome+'s AI analysis, SmartHome+ will have the conclusions and send a report to users.	Overspecification	Major	Jiuxiang Chen	Closed	2020 7.8
3	When the user's heart rate is too fast, blood pressure is too high, sleep time is insufficient, the body lacks water, etc., the user will be prompted.	Inadequacy	Minor	Jiuxiang	Open	2020 7.8
4	1. The air purified system will not work once people select "sleeping mode" (noisy problem-solution).	Weak Conflict	Minor	Junwei Zhang	Open	2020.7.10

	2. When the indoor air quality is excellent, turn off the air purifier. Otherwise, always turn on the air purifier.					
5	1. When the smoke alarm is on, windows will open automatically. 2. When it is raining outside, windows will automatically close.	Weak Conflict	Minor	Junwei Zhang	Closed	2020.7.10
6	Doors and windows are automatically locked when closed.	Unintelligibility	Minor	Junwei Zhang	Open	2020.7.10
7	When the user is sleeping, the curtain shall be closed, the lights shall be off, the system shall keep the environment quiet enough.	Opacity	Minor	Yilin Li	Closed	2020.07.10
8	When the indoor air quality is not good, turn on the air purifier.	Inadequacy	Minor	Yilin Li	Closed	2020.07.12
9	1. The curtain stops closing or opening when it comes to obstacles. 2. When the brightness outside the window is greater than the brightness inside, open the curtains. 3. When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quite enough.	Weak conflict	Minor	Yilin Li	Closed	2020.07.12
10	1:The temperature	Weak conflict	Major	Xianqi	Closed	2020.07.12

				Zhang		
	control system shall turn on the air conditioning and close all the windows, if the temperature is not between 19 and 25 degrees, and the default temperature can be set by the user manually. 2:When the user wakes up, the curtain and windows would be open automatically for ventilation.					
11	The setLights method must be invoked on receipt of a turnOffLights message	Overspecification	Minor	Yilun Sun	Closed	2020.07.12
12	1. If the room temperature is not close to the user-defined temperature, the air conditioner will be turned on to heat/cool the room to adjust the temperature. 2. The humidity will be adjusted to keep it at a level that is at least 30%, but no more than 70%, turn on the air conditioner to decrease the humidity, turn on the humidifier to increase the humidity.	Weak conflict	Minor	Yilun Sun	Closed	2020.07.12

13	1. When the user is sleeping, the curtain shall be closed, the lights shall be off, the system shall keep the environment quite enough. 2..The security system shall make an and notify the user and authorized third parties when an illegal break-in is detected. 3. When the smoke alarm or water leak alarm is activated, the security system shall not only make alarm sound but also send a notification by the remote device.	Weak conflict	Major	Xianqi Zhang	Closed	2020.07.13
14	1. The air purified system will not work once people select "sleeping mode"	Overspecification	Minor	Xianqi Zhang	Open	2020.07.13

| 15 | 1. The energy-saving system shall turn off all the lighting when the users are not at home and the light shall be off if the natural light from outside is bright enough.
2. When the media and entertainment system is on, the lighting would be adjusted to the responding atmosphere mode(eg.movie mode, karaoke mode). | Weak conflict | Minor | Xianqi Zhang | Closed | 2020.07.13 |

INSPECTION SUMMARY REPORT

Project:SmartHome+ Delivery 2
General:

Total Number of open defects_____4_____
Total Number of open conflicts_____1_____
Total Number of close defects_____4_____
Total Number of close conflicts_____7_____

Summarize the number of defects by defect type and conflict type [2][3]

Defect type	Number of open defects	Number of close defects
Overspecification	1	2
Opacity	0	1
Unintelligibility	1	0
Inadequacy	1	1
Omission	1	0

Conflict type	Number of open conflicts	Number of close conflicts
Weak conflict	1	6

Total Person-Hours expended in inspection_____6_____

The requirements after correcting defects

Requirement No.	Requirement description
1	The temperature control system shall turn on the air conditioning and close all the windows, if the temperature is not between 19 and 25 degrees, and the default temperature can be set by the user manually.
2	When the indoor air quality is not good, turn on the air purifier.
3	The air purified system will not work once people select "sleeping mode"
4	The SmartHome+ will always turn on the water purification equipment once people open taps at home.
5	The curtain stops closing or opening when it comes to obstacle
6	When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quiet enough.
7	The energy-saving system shall turn off all the lighting when the users are not at home and the light shall be off if the natural light from outside is bright enough.
8	The security system shall make an alarm and notify the user and authorized third parties when a related illegal break-in is detected.
9	The security system shall turn off the main gas/water valve if gas/water leakage is detected.
10	When the smoke alarm is on, windows will open automatically
11	Doors and windows are automatically locked when closed.
12	When smoke or water leak is detected, the security system shall not only make alarm sounds but also send a notification by the remote device.
13	When the healthy conditions of people are abnormal(eg.heart rate too fast, blood pressure too high), the system shall notify the user immediately.
14	When the user is not at home, the automatic coffee making in the morning will be cancelled.
15	The SmartHome+ can record the normal pets' activity track and store the data. Once the pet's track is abnormal according to the

	SmartHome+'s AI analysis, SmartHome+ will have the conclusions and send a report to users.
16	When there are only pets inside the rooms, only "pets health" and "security" functions shall be reserved.
17	When the media and entertainment system is on, the lighting would be adjusted to the responding atmosphere mode(eg.movie mode, karaoke mode).
18	When it is raining outside, windows will automatically close.

Task2 Documenting conflicts

Statement	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	Total
S1	0	0	0	0	0	0	0	0	0	1	1000	0	0	0	0	0	0	1000	2001
S2	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S3	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
S4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S5	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1
S6	0	0	0	0	1	0	1000	1	0	0	0	1	0	0	0	0	1000	0	2003
S7	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	0	0	1	0	1001
S8	0	0	0	0	0	1	0	0	1000	0	0	1000	0	0	0	1000	0	0	3001
S9	0	0	0	0	0	0	0	1000	0	0	0	1000	0	0	0	1000	0	0	3000
S10	1	0	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	1	1002
S11	1000	0	0	0	0	0	0	0	0	1000	0	0	0	0	0	0	0	0	2000
S12	0	0	0	0	0	1	0	1000	1000	0	0	0	0	0	0	1000	0	0	3001
S13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
S16	0	0	0	0	0	0	0	1000	1000	0	0	1000	0	0	0	0	0	0	3000
S17	0	0	0	0	0	1000	1	0	0	0	0	0	0	0	0	0	0	0	1001
S18	1000	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	1001
Total	2001	1	1	0	1	2003	1001	3001	3000	1002	2000	3001	0	0	0	3000	1001	1001	22014

Interaction matrix

Task 3: Conflict Resolution

3.1 Conflict between S1 and S10

S1: The temperature control system shall turn on the air conditioning and close all the windows, if the temperature is not between 19 and 25 degrees, and the default temperature can be set by the user manually.

S10: When the smoke alarm is on, windows will open automatically

The conflict between S1 and S10 is that the window condition is not clear when the temperature indoor is not suitable and the smoke alarm is on.

- Drop lower-priority conflicting statements

To avoid the conflict of opening and closing windows, the operation of the closing windows when the air conditioner is on could be dropped, as the security system shall share a higher priority than the temperature control system. Therefore, the conflict can be resolved by changing S1 to the following requirement below:

The temperature control system shall turn on the air conditioning, if the temperature is not between 19 and 25 degrees, and the default temperature can be set by the user manually.

- Weaken conflicting statements

As we said above, the security system shall share a higher priority than the temperature control system. The S1 can be changed to the requirement below:

The temperature control system shall turn on the air conditioning, if the temperature is not between 19 and 25 degrees, and the default temperature can be set by the user manually. The windows shall keep closed unless the security system makes an opening command.

- Restore conflicting statements

With this tactic, the windows would be open first when the smoke alarm is on and would send a notification to the user with options about whether to close the windows or not when the air conditioner is on.

3.2 Conflict between S2 and S3

S2: When the indoor air conditioning isn't good, turn on the air purifier.

S3: The air purified system will not working once people select "sleeping mode" (noisy problem solution)

The conflict between S2 and S3 is air purifier operation status is not clear when we turn on "sleeping mode" during the night but the air conditioning is not good.

- Drop lower-priority statements

To avoid the conflict of turning on/off the air purifier, The statement S2 could be dropped, as the statement S3 happening it will have a higher priority to S2.

● Weaken conflicting statements

We could make statement S2 less restrictive so that the conflict no longer exists, for example, "The air purifier will turn on when the indoor air conditioning isn't good unless the Users want to enter quiet mode"

3.3 Conflict between S5 and S6

S5: The curtain stops closing or opening when it comes to obstacle

S6: When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quiet enough.

When the user is going to sleep but there are obstacles on the path of the curtain conflict that will happen under this situation. Cause in this case, the curtain shall stop closing because of obstacles but should remain closed for the sake of users.

● Restore conflicting statements

When the curtain gets stuck during closing or opening, it will alarm the user and ask the user to remove the obstacles manually, which is not a very good way to solve conflict cause it may disturb the user and make such noise.

● Weaken conflicting statements

Making statement S6 less restrictive that it will close the curtain unless the curtain can't be closed by detecting the obstacles in advance. In this way, we manage to complete the statement S5 since it will damage the curtain causing malfunction if the curtain continues closing.

3.4 Conflict between S6 and S8, S12

S6: When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quiet enough.

S8: The security system shall make an alarm and notify the user and authorized third parties when a related illegal break-in is detected.

S12: When smoke or water leak is detected, the security system shall not only make alarm sounds but also send a notification by the remote device.

Actually, the conflicts between S6 and S8, S12 are similar. Due to the requirement for a quiet sleeping environment, the security alarm seems to be noisy for users. However, the security system shall highest priority when serious security issues happen, the user shall be informed at once.

● Specialize in conflict source or target

Make a compliment for S6: Wake up the users when serious security issues happen.

3.5 Conflict between S7 and S17

S7: The energy-saving system shall turn off all the lighting when the users are not at home and the light shall be off if the natural light from outside is bright enough.

S17: When the media and entertainment system is on, the lighting would be adjusted to the responding atmosphere mode(eg.movie mode, karaoke mode).

According to the priority set before, the energy-saving system shares a higher priority than the media and entertainment system. However, if the user wants to enjoy the media and entertainment system during the day time, the lighting mode would be vague because the natural light tends to be enough to keep the lights off to save electricity.

● Weaken conflicting statements

The conflict occurs because the bright natural light and the media and entertainment lighting mode commands meet these two requirements at the same time.

To eliminate the boundary condition, when the user wants to enjoy the media and entertainment system during the day time, the energy-saving mode should be turned off manually, otherwise, the media and entertainment system would only reserve the main function without related lighting mode.

● Restore conflicting statements

In this case, we decide to save more unnecessary costs for users by forcing the entertainment lighting mode to be off when this conflict is occurring, because the responding lighting would be not obvious if the natural light is too bright and be redundant due to that.

3.5 Conflict between S10 and S18

S10: When the smoke alarm is on, windows will open automatically (risk analysis)

S18: When it is raining outside, windows will automatically close.

The conflict happens when it's raining outside and the smoke alarm is on at the same time. The windows will fail its function since the open/close status is ambiguous.

● Drop lower-priority statements

We could make a statement S10 the highest priority since it is related to a security problem, and the statement S18 could be dropped.

● Weaken conflicting statements

We could also let statement S18 be less restrictive like: the windows will automatically close when it comes to rain unless the emergency inside the house happens.

Task 4 Conflict evaluation

4.1 Resolutions evalution of S1 and S10

S1: The temperature control system shall turn on the air conditioning and close all the windows, if the temperature is not between 19 and 25 degrees, and the default temperature can be set by the user manually.

S10: When the smoke alarm is on, windows will open automatically

Evaluation criteria NFR	Significance weighting	S1: Drop the operation of the closing windows in the air conditioning system	S1: The windows shall keep closed unless the security system makes an opening command
Comfortable Temperature	0.15	0.2	0.7
Energy-Saving	0.05	0.1	0.5
Safety	0.6	0.8	0.65
Reaction time	0.2	0.2	0.5
Total	1.0	0.555	0.62

Apply the second proposal "The windows shall keep closed unless the security system makes an opening command".

4.2 Resolutions evalution of S2 and S3

S2: When the indoor air conditioning isn't good, turn on the air purifier.

S3: The air purified system will not working once people select "sleeping mode"

Evaluation criteria NFR	Significance weighting	drop S2 and reserve S3	combine S2 and S3: The air purifier will turn on when the indoor air conditioning isn't good unless the users want to enter quiet mode
Noise volume	0.6	0.9	0.6
Air quality	0.3	0.01	0.85
Energy-Saving	0.1	0.4	0.1
Total	1.0	0.583	0.625

Apply the second proposal "The air purifier will turn on when the indoor air conditioning isn't good unless the users want to enter quiet mode".

4.3 Resolutions evalution of S5 and S6

S5: The curtain stops closing or opening when it comes to obstacle

S6: When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quiet enough.

Evaluation criteria NFR	Significance weighting	If the curtain get stucks during opening or closing, notify the user	Detecting obstacles before closing the curtains
Hardware Cost	0.3	0.9	0.2
life-span	0.3	0.2	0.8
user friendly	0.4	0.2	0.8
Total	1.0	0.41	0.62

Apply the second proposal "Detecting obstacles before closing the curtains, when the curtain shall be closed".

4.4 Resolutions evalution of S6 and S8 and S12

S6: When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quiet enough.

S8: The security system shall make an alarm and notify the user and authorized third parties when a related illegal break-in is detected.

S12: When smoke or water leak is detected, the security system shall not only make alarm sounds but also send a notification by the remote device.

In order to guarantee the safety of users, we consider to complete the S8 to the following requirement: When the user is sleeping, the curtain shall be closed, the lights shall be off, and the system shall keep the environment quiet enough. Moreover, wake up the users when serious security issues happen.

4.5 Resolutions evalution of S7 and S17

S7: The energy-saving system shall turn off all the lighting when the users are not at home and the light shall be off if the natural light from outside is bright enough.

S17: When the media and entertainment system is on, the lighting would be adjusted to the responding atmosphere mode(eg.movie mode, karaoke mode).

Evaluation criteria NFR	Significance weighting	User could turn off the electricity-saving mode manually for entertainment lighting atmosphere	The system will force the entertainment lighting to be off
Entertainment atmosphere	0.65	0.85	0.15
Energy-Saving	0.05	0.02	0.5
life-span	0.3	0.1	0.7
Total	1.0	0.5835	0.3325

Apply the first proposal "User could turn off the electricity-saving mode manually for entertainment lighting atmosphere".

4.6 Resolutions evalution of S10 and S18

S10: When the smoke alarm is on, windows will open automatically.

S18: When it is raining outside, windows will automatically close.

Evaluation criteria NFR	Significance weighting	Drop S18: ignore the operation of the closing windows from rain detection	S18: the windows will automatically close when it comes to rain unless the emergency inside the house happens.
Safety	0.4	0.8	0.7

Reaction time	0.2	0.5	0.4
Avoid exterior water leaking	0.4	0.1	0.9
Total	1.0	0.46	0.72

Apply the second proposal " the windows will automatically close when it comes to rain unless the emergency inside the house happens".

Task 5 Risk management

5.1 Risk identification[5]

● **The security system shall turn off the main gas/water valve if gas/water leakage is detected.**

Some normal operations would be affected due to that, and the operation of closing the main water valve may not solve the risk of exterior water leaking.

When the washing machine is operating, the SmartHome+ detects water leaking, though the water leaking is not from the laundry room and even from the exterior, the operation of closing the main water valve automatically would cause the washing machine to work improperly and even result in machine damage.[4]
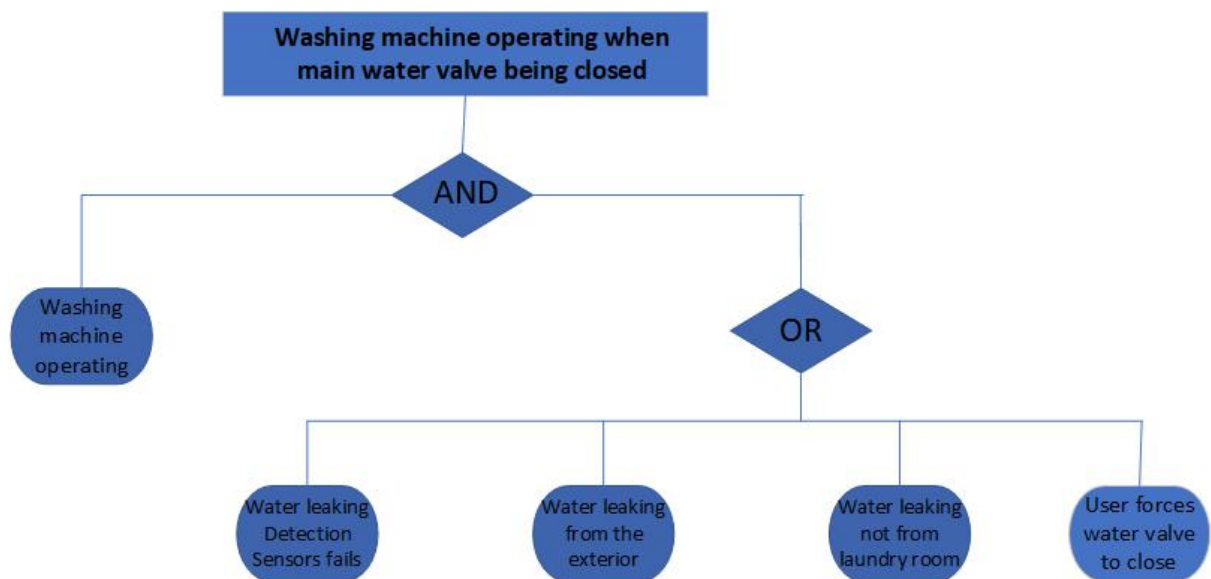
● **When the smoke alarm is on, windows will open automatically.**

When the smoke alarm is triggered, the window control system fails or there are obstructions at the window which prevents it from opening.
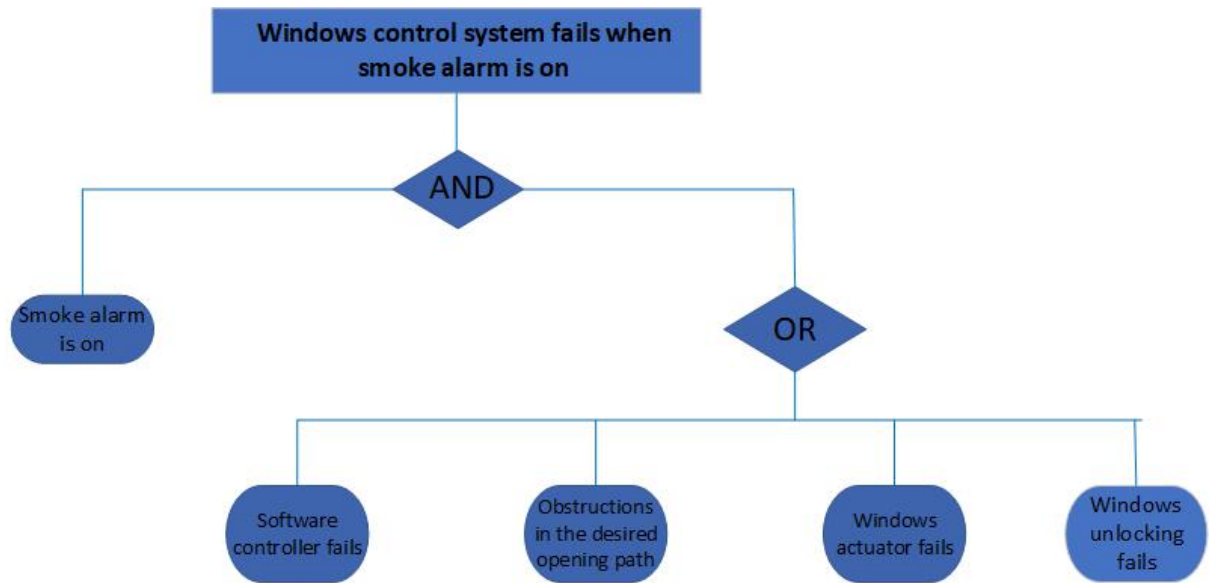
- **The security alarms and notifications fail when an illegal break-in occurs because of the monitor's identification failure or alarm system failure.**
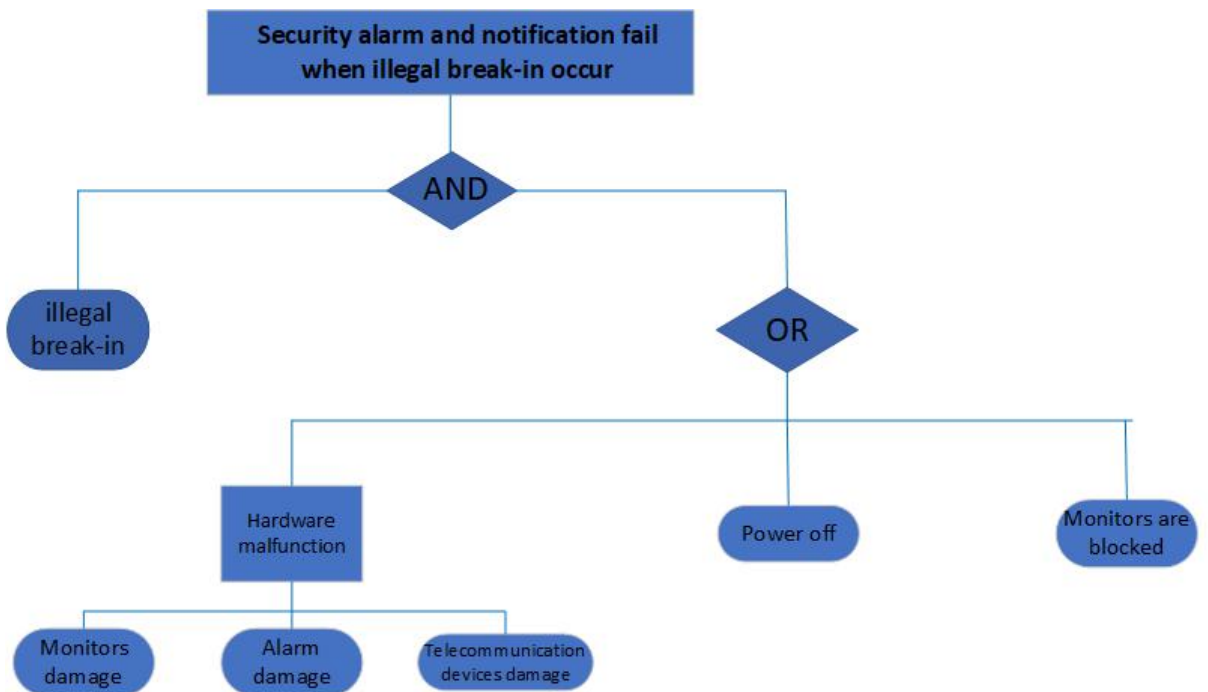
- **If the SmartHome+ system is controlled by others, great damage and the loss of life and property would be caused.**
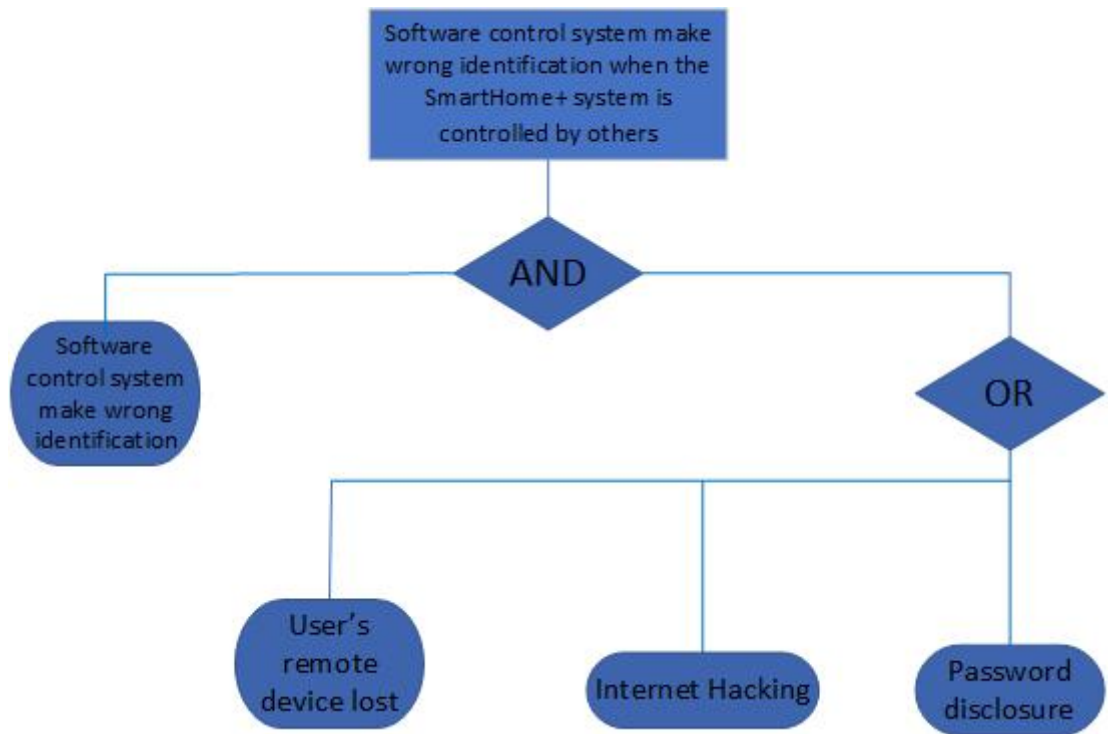
- **When the temperature system fails, it will cause abnormal temperatures indoors. If only children are not home, their health would be impaired.**

```
                    ┌─────────────────────┐
                    │   When indoors      │
                    │ temperature is      │
                    │ abnormal,           │
                    │ temperature control │
                    │ system fails to     │
                    │ operate correctly   │
                    └─────────────────────┘
                              │
                           ◆ AND ◆
```

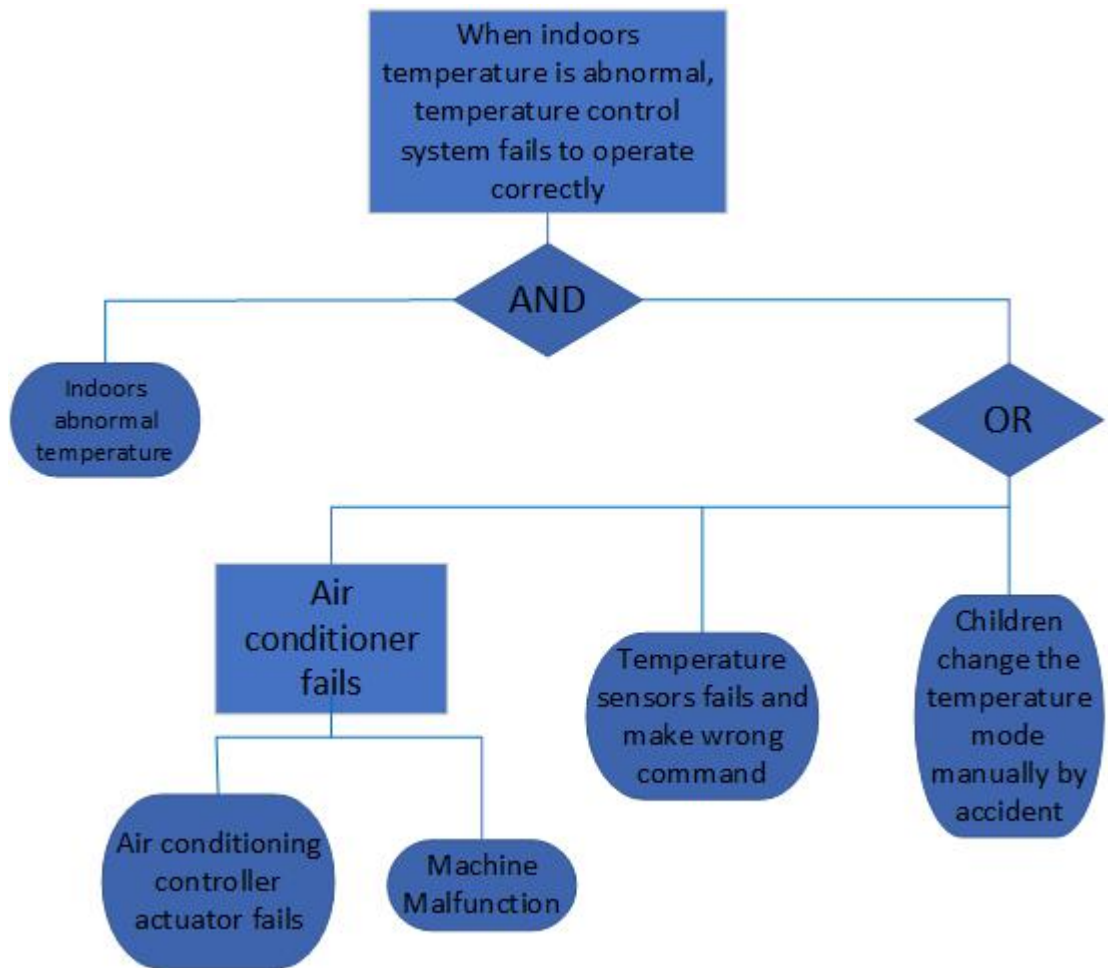When indoors temperature is abnormal, temperature control system fails to operate correctly

AND

- Indoors abnormal temperature

OR

- Air conditioner fails
  - Air conditioning controller actuator fails
  - Machine Malfunction
- Temperature sensors fails and make wrong command
- Children change the temperature mode manually by accident

● **When the whole SmartHome+ system is operating, if there is a power outage or network disconnection, the entire system cannot operate normally.**
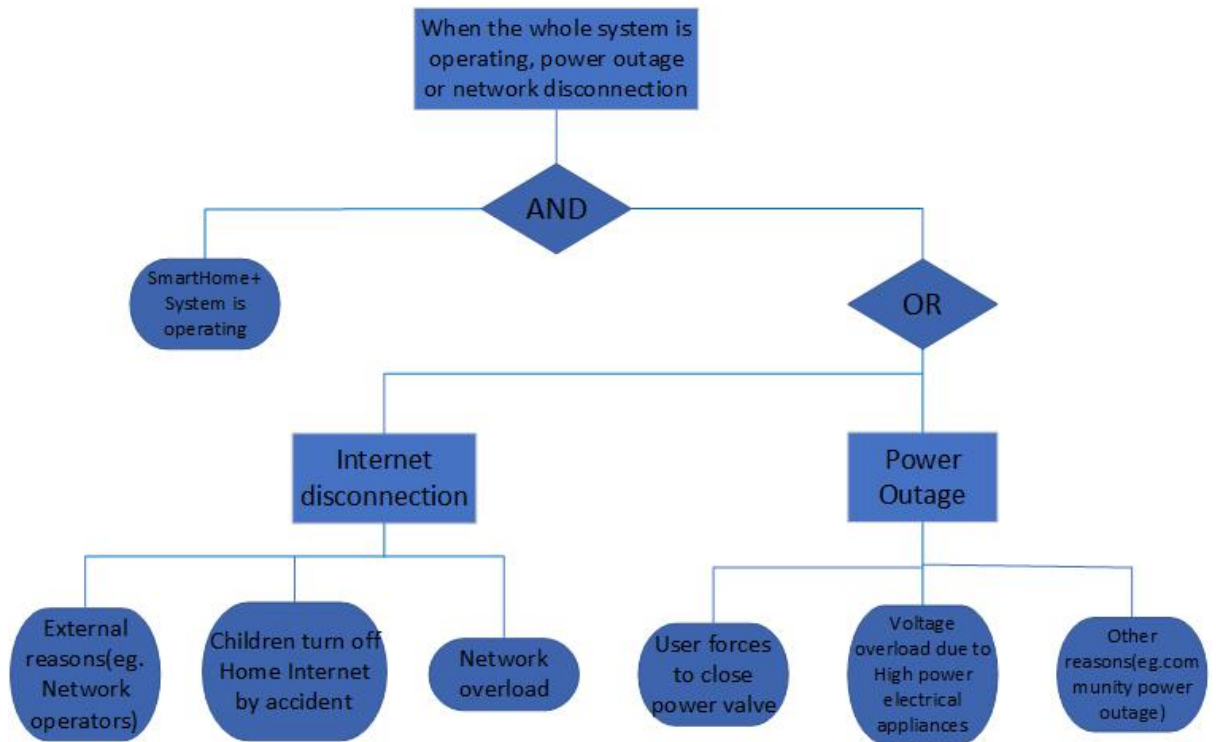
5.2 Risk assessment

● **Washing machine or dishwasher is operating when the main water valve is closed because of water leakage detected.**

Consequences	Likely	Possible	Unlikely
Lost property	Moderate	Moderate	Low
Machine damage	High	High	Low

The washing machine or dishwasher would operate abnormally because of the shut down of water input due to the water valve being closed, which might result in the damage of these electrical appliances.

● **When the smoke alarm is triggered, the window control system fails or there are obstructions at the window which prevents it from opening.**

Consequences	Likely	Possible	Unlikely
Loss of life	Catastrophic	Catastrophic	Severe
Serious injuries	Catastrophic	Severe	High
Impaired health	High	High	Low

Feel uncomfortable	High	High	Low
Machine damage	Moderate	Moderate	Low
Energy waste	Moderate	Moderate	Low

If the window controller system fails, the smoke would be full of the house without open windows. The polluted air would impair users' health and even result in fire which threaten people's property and lives.

- **The security alarms and notifications fail when an illegal break-in occurs because of the monitor's identification failure or alarm system failure.**

Consequences	Likely	Possible	Unlikely
Loss of life	Catastrophic	Catastrophic	Severe
Serious injuries	Catastrophic	Severe	High
Lost property	High	High	Low
Machine damage	High	Low	Low

If someone else breaks into the house illegally, the user's life would be seriously threatened, because he/she may be with a weapon as a robber. Moreover, users would lose property due to the thief's break-in.

- **If the SmartHome+ system is controlled by others, great damage and the loss of life and property would be caused.**

Consequences	Likely	Possible	Unlikely
Loss of life	Catastrophic	Catastrophic	Severe
Serious injuries	Catastrophic	Severe	High
Impaired health	High	High	Low
Feel uncomfortable	High	High	Low
Lost property	High	Moderate	Low
System crashed	High	High	Low

Machine damage	Moderate	Low	Low

If someone else controls the whole SmartHome+ system because of several causes we listed in the risk tree, we even have to consider all the consequences in the table, the internet security and system security is the base for all the core functions.

- **When the temperature system fails, it will cause abnormal temperatures indoors. If only children or pets are at home, their health would be impaired.**

Consequences	Likely	Possible	Unlikely
Impaired health	High	High	Low
Feel uncomfortable	High	High	Low
Machine damage	Moderate	Moderate	Low

Living environment with abnormal temperature would be uncomfortable and impair the users' health, especially children and pets' health when they are left at home alone.

- **When the whole SmartHome+ system is operating, if there is a power outage or network disconnection, the entire system cannot operate normally.**

Consequences	Likely	Possible	Unlikely
Loss of life	Low	Low	Low
Serious injuries	Moderate	Low	Low
Impaired health	High	Moderate	Low
Feel uncomfortable	High	High	Low
Lost property	Moderate	Moderate	Low
System crashed	High	High	Low
Machine damage	Moderate	Moderate	Low

As this SmartHome+ is a complex system with multiple interactions between different house areas and function components, Internet disconnection and power outage make huge difficulty for technical maintenance.

5.3 Risk Control

Risk reduction leverage formula: [1]

$$Risk\ reduction\ leverage\ (RRL) = \frac{RE_{before} - RE_{after}}{Cost\ of\ risk\ reduction}$$

$$RE = risk\ probability \times amount\ at\ stake$$

- **Washing machine or dishwasher is operating when the main water valve is closed because of water leakage detected.**

The probability of machine damage and lost property is 15%. The cost of repairing the machine or changing a new one is estimated at 2000CAD.

In order to reduce the risk of machine damage and lost property, we proposed the following two options:

Option 1: Set up the circuit and water protection mechanism for electrical appliances, when the water is cut off, the machine will automatically stop running.

Option 2: Every house area shall be equipped with water leakage sensors and water valve, when water leakage is detected, only related areas's water would be cut off.

The first option is estimated to reduce the risk to 10%. It is estimated to cost 125CAD. The second option is estimated to reduce the risk to 5%. It is estimated to cost 120CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=0.8

RRL2=1.67

So the most cost-effective measure is option2.

- **When the smoke alarm is triggered, the window control system fails or there are obstructions at the window which prevents it from opening.**

The probability of the window control system fails and results in health impairment and property damage is 5%. The cost of the recombination system and having doctors if having serious injuries are estimated at 20000CAD.

In order to reduce the risk cost and recombining system, we proposed the following three options:

Option 1: Installing ventilating fans to excrete smoke out of the house.

Option 2: The system regularly (every week) checks the effectiveness of the various sub-system components and reminds the user to update the hardware equipment at intervals (for example, every three months).

Option 3: Installing fire and smoke control system with related professional devices to avoid cost from smoke and fire results from it.

The first option is estimated to reduce the risk to 4%. It is estimated to cost 200CAD. The second option is estimated to reduce the risk to 2%. It is estimated to cost 400CAD. The third option is estimated to reduce the risk to 1%. It is estimated to cost 2000CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=1

RRL2=1.5

RRL3=0.4

So the most cost-effective measure is option2.

- **The security alarms and notifications fail when an illegal break-in occurs because of the monitor's identification failure or alarm system failure.**

The probability of security alarms and notifications fail is 15%. The cost of having doctors if having serious injuries and lost properties are estimated at 20000CAD.

In order to reduce the risk of serious injuries and lost properties, we proposed the following two options:

Option1: One-key call-police alarm function is set to facilitate users to call the police in time when the user finds that the property is stolen.

Option2: Use two monitoring systems for monitoring and reminding separately indoors and outdoors.

The first option is estimated to reduce the risk to 5%. It is estimated to cost 1500CAD. The second option is estimated to reduce the risk to 10%. It is estimated to cost 1500CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=1.33

RRL2=0.67

So the most cost-effective measure is option1.

- **If the SmartHome+ system is controlled by others, great damage and the loss of life and property would be caused.**
  - **for system and security:**

The probability of the system being controlled by others is 15%. The cost of recombining the system is estimated at 10000CAD.

In order to reduce the risk of recombination systems, we proposed the following three options:

Option 1: Set up the system automatic restart mechanism.

Option 2: Frequent backup data.

Option 3: The system is regularly upgraded and reminds the user to change the password at intervals (for example, every two months).

The first option is estimated to reduce the risk to 8%. It is estimated to cost 500CAD. The second option is estimated to reduce the risk to 10%. It is estimated to cost 500CAD. The third option is estimated to reduce the risk to 1%. It is estimated to cost 8000CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=1.4

RRL2=1

RRL3=1.75

So the most cost effective measure is option3.

- **For health and environment:**

The probability of the system being controlled by others is 5%. The cost of having doctors if the health is impaired is estimated at 10000CAD.

In order to reduce the risk of impaired health, we proposed the following two options:

Option 1: When the user is at home and the temperature is too high (more than 25 degrees) or too low (less than 19 degrees) for a long time (for example, more than 4 hours), or the air quality is poor(AQI greater than 100) for a long time, the air conditioner or air purifier is forced to turn on and send notifications to users.

Option 2: When the user's health monitoring indicators (heart rate, blood pressure, etc.) are abnormal, the system sends an alert to the user. When the value is in a dangerous state, the user is directly alerted to the doctor.

The first option is estimated to reduce the risk to 0.5%. It is estimated to cost 250CAD. The second option is estimated to reduce the risk to 4%. It is estimated to cost 700CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=1.8

RRL2=0.14

So the most cost-effective measure is option1.

- **When the temperature system fails, it will cause abnormal temperatures indoors. If only children or pets are at home, their health would be impaired.**

The probability of the temperature system failing is 5%. The cost of having doctors if the health is impaired is estimated at 10000CAD.

In order to reduce the risk of impaired health, we proposed the following two options:

Option 1: The system sends an analysis report (temperature, humidity, air quality, noise volume, etc.) to users everyday and seeks feedback on user experience, and regularly upgrades the system version.

Option 2: When the health monitoring indicators (heart rate, blood pressure, etc.) for user/baby/pet are abnormal, the system sends an alert to the user. When the value is in a dangerous state, the user is directly alerted to the doctor.

The first option is estimated to reduce the risk to 0.5%. It is estimated to cost 250CAD. The second option is estimated to reduce the risk to 4.5%. It is estimated to cost 500CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=1.8

RRL2=0.1

So the most cost-effective measure is option1.

- **When the whole SmartHome+ system is operating, if there is a power outage or network disconnection, the entire system cannot operate normally.**

The probability of the system crashing is 15%. The cost of the recombination system is estimated at 400CAD.

In order to reduce the risk of system crashing, we proposed the following three options:

Option 1: Set up the system automatic restart mechanism.

Option 2: Frequent backup data.

Option 3: An additional battery-powered alarm is added. When the power is cut off or the network is disconnected, the alarm sounds.

The first option is estimated to reduce the risk to 8%. It is estimated to cost 50CAD. The second option is estimated to reduce the risk to 10%. It is estimated to cost 50CAD. The third option is estimated to reduce the risk to 1%. It is estimated to cost 30CAD.

Through risk reduction leverage formula, we calculated that:

RRL1=0.56

RRL2=0.4

RRL3=1.87

So the most cost effective measure is option3.

5.4 Risk Documentation

- **Washing machine or dishwasher is operating when the main water valve is closed because of water leakage detected.**
    - **The conditions or events characterizing its occurrence**
      The washing machine is likely to be damaged when there are edged objects or clothes with rigid metal in it, the spinning energy emitted by the washing machine would cause damage to the surrounding cylinder.

The washing machine or dishwasher would operate abnormally because of the shut down of water input due to the water valve being closed, which might result in the damage of these electrical appliances.

- **Its estimated likelihood of occurrence**

  The probability of machine damage and lost property is 15%.

- **The estimated likelihood and severity of each possible consequence**

Consequences	Likely	Possible	Unlikely
Lost property	Moderate	Moderate	Low
Machine damage	High	High	Low

- **The countermeasures that were identified together with their respective risk-reduction leverage**

  Option 1: Set up the circuit and water protection mechanism, when the power or water is cut off, the machine will automatically stop running.

  RRL1 = 0.8

  Option 2: When there is a power outage or water outage, the system warns the user.

  RRL2 = 1.67

- **The selected subset of countermeasures**

  Option 2

- When the smoke alarm is triggered, the window control system fails or there are obstructions at the window which prevents it from opening.

  - **The conditions or events characterizing its occurrence**

    There are some chances when people could get serious injuries inside the house. It could happen when people take a shower and slip down on the floor,or people get electric when they are trying to change the light bulbs, even their pets sometimes could bite them and cause bleeding seriously.

    If the window controller system fails, the smoke would be full of the house without open windows. The polluted air would impair users' health and even result in fire which threaten people's property and lives.

  - **Its estimated likelihood of occurrence**

    The probability of the window control system fails is 5%.

  - **The estimated likelihood and severity of each possible consequence**

Consequences	Likely	Possible	Unlikely

	Catastrophic	Catastrophic	Severe
Loss of life	Catastrophic	Catastrophic	Severe
Serious injuries	Catastrophic	Severe	High
Impaired health	High	High	Low
Feel uncomfortable	High	High	Low
Machine damage	Moderate	Moderate	Low
Energy waste	Moderate	Moderate	Low

- **The countermeasures that were identified together with their respective risk-reduction leverage**

Option 1: Installing ventilating fans to excrete smoke out of the house.

RRL1 = 1

Option 2: The system regularly (every week) checks the effectiveness of the various sub-system components and reminds the user to update the hardware equipment at intervals (for example, every three months).

RRL2 = 1.5

Option 3: Installing fire and smoke control system with related professional devices to avoid cost from smoke and fire results from it.

RRL3 = 0.4

- **The selected subset of countermeasures**

Option 2

- **The security alarms and notifications fail when an illegal break-in occurs because of the monitor's identification failure or alarm system failure.**

  - **The conditions or events characterizing its occurrence**

  If someone else breaks into the house illegally, the user's life would be seriously threatened, because he/she may be with a weapon as a robber. Moreover, users would lose property due to the thief's break-in.

  - **Its estimated likelihood of occurrence**

  The probability of security alarms and notifications fail is 15%.

  - **The estimated likelihood and severity of each possible consequence**

Consequences	Likely	Possible	Unlikely
Loss of life	Catastrophic	Catastrophic	Severe

Serious injuries	Catastrophic	Severe	High
Lost property	High	High	Low
Machine damage	High	Low	Low

- **The countermeasures that were identified together with their respective risk-reduction leverage**

  Option1: One-key call-police alarm function is set to facilitate users to call the police in time when the user finds that the property is stolen.

  RRL1 = 1.33

  Option2: Use two monitoring systems for monitoring and reminding separately indoors and outdoors.

  RRL2 = 0.67

- **The selected subset of countermeasures**

  Option 2

- **If the SmartHome+ system is controlled by others, great damage and the loss of life and property would be caused.**

  - **The conditions or events characterizing its occurrence**

    If someone else controls the whole SmartHome+ system because of several causes we listed in the risk tree, we even have to consider all the consequences in the table, the internet security and system security is the base for all the core functions.

  - **Its estimated likelihood of occurrence**

    The probability of the system being controlled by others is 15%.

  - **The estimated likelihood and severity of each possible consequence**

Consequences	Likely	Possible	Unlikely
Loss of life	Catastrophic	Catastrophic	Severe
Serious injuries	Catastrophic	Severe	High
Impaired health	High	High	Low
Feel uncomfortable	High	High	Low
Lost property	High	Moderate	Low
System crashed	High	High	Low

Machine damage	Moderate	Low	Low

- **The countermeasures that were identified together with their respective risk-reduction leverage**

For system and security:

Option 1: Set up the system automatic restart mechanism.

RRL1 = 1.4

Option 2: Frequent backup data.

RRL2 = 1

Option 3: The system is regularly upgraded and reminds the user to change the password at intervals (for example, every two months).

RRL3 = 1.75

For health and environment:

Option 1: When the user is at home and the temperature is too high (more than 25 degrees) or too low (less than 19 degrees) for a long time (for example, more than 4 hours), or the air quality is poor(AQI greater than 100) for a long time, the air conditioner or air purifier is forced to turn on and send notifications to users.

RRL1 = 1.8

Option 2: When the user's health monitoring indicators (heart rate, blood pressure, etc.) are abnormal, the system sends an alert to the user. When the value is in a dangerous state, the user is directly alerted to the doctor.

RRL2 = 0.14

- **The selected subset of countermeasures**

For system and security: option 3

For health and environment: option 1

- When the temperature system fails, it will cause abnormal temperatures indoors. If only children or pets are at home, their health would be impaired.

  - **The conditions or events characterizing its occurrence**

    Living environment with abnormal temperature would be uncomfortable and impair the users' health, especially children and pets' health when they are left at home alone.

  - **Its estimated likelihood of occurrence**

    The probability of feeling uncomfortable is 5%.

  - **The estimated likelihood and severity of each possible consequence**

Consequences	Likely	Possible	Unlikely

Impaired health	High	High	Low
Feel uncomfortable	High	High	Low
Machine damage	Moderate	Moderate	Low

- **The countermeasures that were identified together with their respective risk-reduction leverage**

  Option 1: The system sends an analysis report (temperature, humidity, air quality, noise volume, etc.) to users everyday and seeks feedback on user experience, and regularly upgrades the system version.

  RRL1 = 1.8

  Option 2: When the health monitoring indicators (heart rate, blood pressure, etc.) for user/baby/pet are abnormal, the system sends an alert to the user. When the value is in a dangerous state, the user is directly alerted to the doctor.

  RRL2 = 0.1

- **The selected subset of countermeasures**

  Option 1

- **When the whole SmartHome+ system is operating, if there is a power outage or network disconnection, the entire system cannot operate normally.**

  - **The conditions or events characterizing its occurrence**

    As this SmartHome+ is a complex system with multiple interactions between different house areas and function components, Internet disconnection and power outage make huge difficulty for technical maintenance.

  - **Its estimated likelihood of occurrence**

    The probability of the system crashing is 15%.

  - **The estimated likelihood and severity of each possible consequence**

Consequences	Likely	Possible	Unlikely
Loss of life	Moderate	Low	Low
Serious injuries	Moderate	Low	Low
Impaired health	High	Moderate	Low
Feel uncomfortable	High	High	Low

Lost property	Moderate	Moderate	Low
System crashed	High	High	Low
Machine damage	Moderate	Moderate	Low

- **The countermeasures that were identified together with their respective risk-reduction leverage**

  Option 1: Set up the system automatic restart mechanism.

  RRL1 = 0.56

  Option 2: Frequent backup data.

  RRL2 = 0.4

  Option 3: An additional battery-powered alarm is added. When the power is cut off or the network is disconnected, the alarm sound

  RRL3 = 1.87

- **The selected subset of countermeasures**

  Option 3

Glossary

AQI: Air Quality Index

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