[78] Qiang Zeng, Jianhai Su, Chenglong Fu, Golam Kayas, Lannan Luo, Xiaojiang Du, Chiu C Tan, and Jie Wu. A multiversion programming inspired approach to detecting audio adversarial examples. In 49th Annual IEEE/IFIP International Conference on Dependable Systems and Networks (DSN), pages 39-51, 2019.

[79] Wei Zhang, Yan Meng, Yugeng Liu, Xiaokuan Zhang, Yinqian Zhang, and Haojin Zhu. Homonit: Monitoring smart home apps from encrypted traffic. In ACM SIGSAC Conference on Computer & Communications Security (CCS), pages 1074-1088, 2018.

[80] Wei Zhou, Yan Jia, Yao Yao, Lipeng Zhu, Le Guan, Yuhang Mao, Peng Liu, and Yuqing Zhang. Discovering

A.2 Training and Testing Results

On Testbed 2, we extract 32 e2e correlation from smart apps and pass 98 correlations from 2064 hypothetical correlations. In total, we get 109 correlations after refining. The difference of correlations regarding contact sensors, as observed on Testbed 1, is also observed on Testbed 2: C1 on the front door always gets closed right after the acceleration is detected, while C2 and C3 are usually left open for a long time. The inaccurate correlation (Eaway presence(PS2) Eswitch(L1) is accepted by the hypothesis testing. If not refined by the smart app rule R2.8, it causes 4 false alarms for HAWatcher (Mining Only) on case 2.3 and 2.6 when

only the resident taking PS2 leaves home. As detailed in

and understanding the security hazards in the inter-

our technical report [44], HAWatcher achieves an aver-

actions between iot devices, mobile apps, and clouds

age detection precision of 94.85% and recall of 96.86%. In

on smart home platforms. In 28th USENIX Security

terms of the false alarm test, HAWatcher raises 13 false

Symposium (USENIX Security), pages 1133-1150, 2019.

alarms among 6721 events collected within one week's test-

ing period, which causes a false alarm rate (FAR) of 0.19%

A

Experimental Results of Testbeds 2 to 4

and 1.86 false alarms per day. Among the 13 false alarms,

acceleration(C1)

four (4) are raised by the correlations active

Table 9: Smart apps deployed on Tesbeds 2 ~ 4. R2.1, for

.motion(MS1)

and

acceleration(C2)

,motion(MS2)

because

example, means the first smart app rule on Testbed 2.

active

active

active

of strong vibrations in the neighborhood that trigger events

Index

Smart app rules

of the acceleration sensor C1 and C2. Three (3) are raised

R2.1

If MS2(active), then P1(on) and L1(on)

R2.2

If MS2(inactive) for 30 minutes,

by (Low illuminance (L4) motion(MS3) inactive because there are three

then P1(off), L1(off), L2(off), L3(off)

times that a resident remains active in the study room after

R2.3

If MS3(active), then L4(on)

contact(C3)

R2.4

If MS3(inactive) for 10 minutes, then L4(off)

the light is turned off. Four (4) are caused by closed

R2.5

If W(wet) or MS3(humidity>55) then V(on)

motion(MS3)

because residents close the door from outside.

R2.6

If V(on) for 15 minutes, then V(off)

active

R2.7

If PS1(present) or PS2(present),

In contrast, the OCSVM-based detector has an average pre-

then turn on L1, L2, L5, P1

cision of 11.11% and recall of 35.41% with 968 false alarms

R2.8

If PS1(away) and S2(away),

then turn off L1, L2, L3, L4, L5, V, P1

raised. The ARM-based detector has an average precision of

R2.9

If B(pressed), toggle L5

3.76% and a recall of 9.96%, and raises 370 false alarms.

R2.10

If B(held), then turn off all L and P

R2.11

If B(double pressed), turn on L1 and L5 and P1

On Testbed 3, HAWatcher accepts 50 correlations from 527

R3.1

If MS1 (active) and Mode(home), then L1(on)

hypotheses, and 15 e2e correlations from smart apps. After re-

R3.2

If MS1 (inactive) for 60 minutes, then ((off)

fining, there are 55 correlations left. HAWatcher achieves an

R3.3

If B(pressed), toggle L1

R3.4

If B(held), then L1(off) and Mode(night)

average detection precision of 92.74% and a recall of 93.36%.

R3.5

If B(double pressed), then L1(on) Mode(home)

Among the testing period, ten (10) false alarms are raised

R3.6

If PS(away), then L1(off), P1(off), and Mode(away)

by HAWatcher among 2411 events, which leads to 1.42 false

R3.7

If PS(present), then L1(on), P1(on), and Mode(home)

alarms per day on average and a FAR of 0.42%. In contrast, the

R4.1

If PS(away), then P1(off) and P2(off)

R4.2

If PS(present) then P1(on), P2(on)

OCSVM-based detector has an average precision of 31.01%

R4.3

If B(pressed), toggle P1

and a recall of 42.33%, and raises 379 false alarms. The ARM-

R4.4

If B(held), toggle P2

based detector has an average precision of 9.89% and an

average recall of 14.10%, and raises 152 false alarms.

A.1 Deployment

On Testbed 4, only 26 correlations are acquired because of

the low density of IoT devices and smart apps. HAWatcher

We list the smart apps deployed on Testbeds 2, 3, and 4 in

gets an average detection precision of 96.62% and a recall of

Table 9. On Testbed 3, the mode is used as a condition to

90.17%. Five (5) false alarms are raised on this testbed among 1674 events, that is, 0.71 false alarms per day and a FAR of 0.30%. In contrast, the OCSVM-based detector has an average precision of 28.80% and a recall of 42.37%, and raises 168 false alarms. The ARM-based detector has an average precision of 3.60% and a recall of 7.38%, and raises 108 false alarms.

control the behavior of the light, while Testbeds 2 and 4 do not use the mode. Since Testbed 2 has two residents, lights and plugs are only turned off when both residents are away (R2.8). Testbeds 3 and 4 have one resident each, and all lights and plugs are turned off when the resident leaves home.