Conférence francophone d'informatique en Parallélisme, Architecture et Système

Contribution à l'adoption des IDS dans l'IoT

Cas d'un contexte grand public de type « smart home »

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Agenda

1 - IoT nodes are first choice targets for attackers

- IoT insights
- IoT inherent weaknesses
- Focus on smart-home ecosystem / Attacks examples

2 - IDS in a nutshell

- Introducing IDS
- Elements of IDS taxonomy
- A few IDS examples

3 - Characteristics of a smart home IDS

- Requirements of a smart-home protection x IDS taxonomy
- Proposed architecture

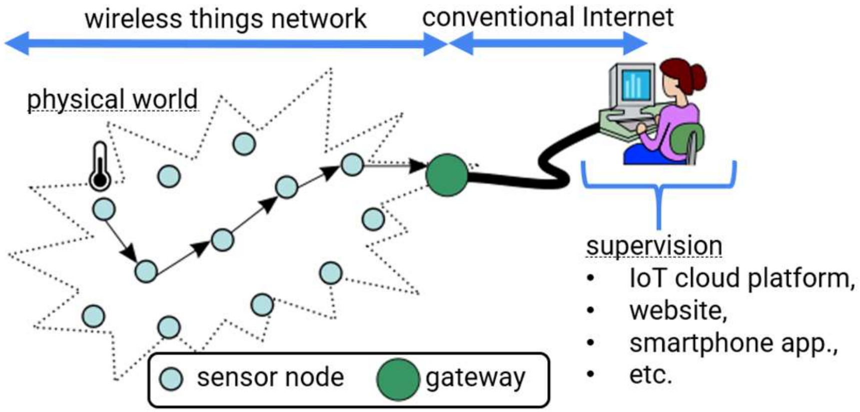
Conclusion, References

1 - IoT and security > IoT insights

What is “*Internet of Things*”? (ENISA, 2017) (Raza et al., 2013)

“ things”, “devices”, “nodes”, “hosts” or “objects” are:

- bridges between physical world and virtual world of supervision,
- communicating microcontrollers, with sensors or actuators,
- organized in wireless networks, often connected to the Internet.



WSN.svg: Public domain, via Wikimedia Commons

IoT:

- pervades all sci-tech fields,
- fosters fast decision making,
- has for 2025 estimation: (Lueth, 2018)
  - 21.5 billions things,
  - $1500 billions sales.

Credit : Internet of Things with Microcontrollers: a hands-on course - INRIA

1 - IoT and security> weaknesses / case of “smart-home” ecosystem

Weaknesses regarding IoT security:

- nodes low resources: ~~RSA~~,
- heterogeneities (µC / FreeRTOS, RIOT, Contiki, etc. / BLE, Zigbee, Wifi, 6LoWPAN, etc.),
- wireless comm. → eavesdropping, message injections, jamming.

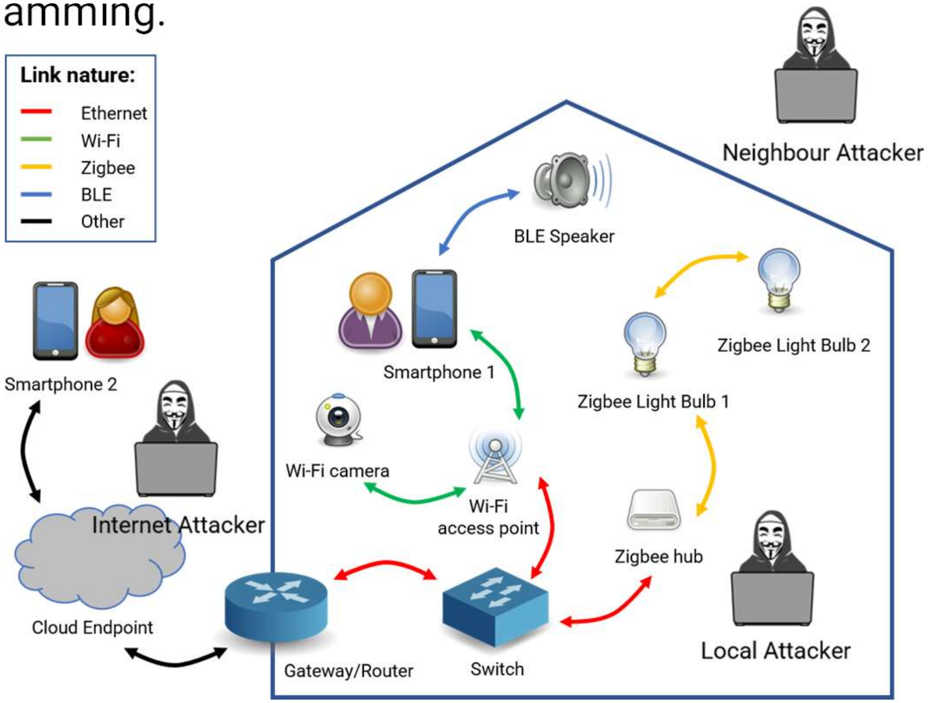
“Smart-home” ecosystem peculiarities:

- several protocol stacks under a small volume,
- a cost-driven market introducing many biases,
- non-technician users.

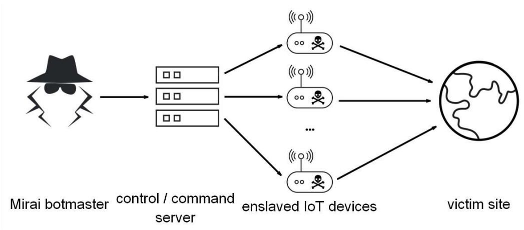
Requirements of a smart-home protection solution:

- coverage of most popular technologies and new ones,
- adapted cost (<100 €),
- standalone in already deployed sites, simple for users.

Threat model (Alrawi et al., 2019)



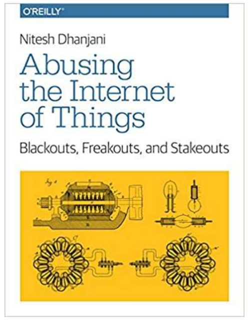
1 - IoT and security > examples of smart-home attacks



2016 – DDoS (Mirai malware)
Webcams default credentials
TCP/IP
(Kolias et al., 2017)

2018 – Door lock takeover
Insecure keys exchange
Z-Wave
(Khandelwal, 2018)

2016 – Confidentiality compromission
TC link key on forums → Network key
Zigbee
(Zillner, 2016)



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Nitesh Dhanjani

Abusing the Internet of Things

Blackouts, Freakouts, and Stakeouts

Attack use cases:
(Dhanjani, 2015)

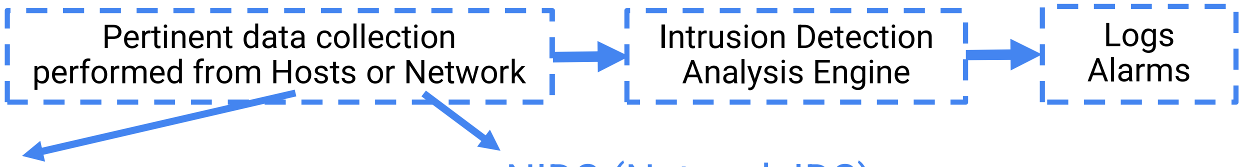
Attack taxonomy:
(Tschofenig and Baccelli, 2019)

There is a need for a first line of defense: Intrusion Detection Systems (IDS)

This presentation: Guidelines for a realistic smart-home IDS, widely adopted

2 - IDS in a nutshell > presentation and taxonomy

An IDS:



Pertinent data collection performed from Hosts or Network

Intrusion Detection Analysis Engine

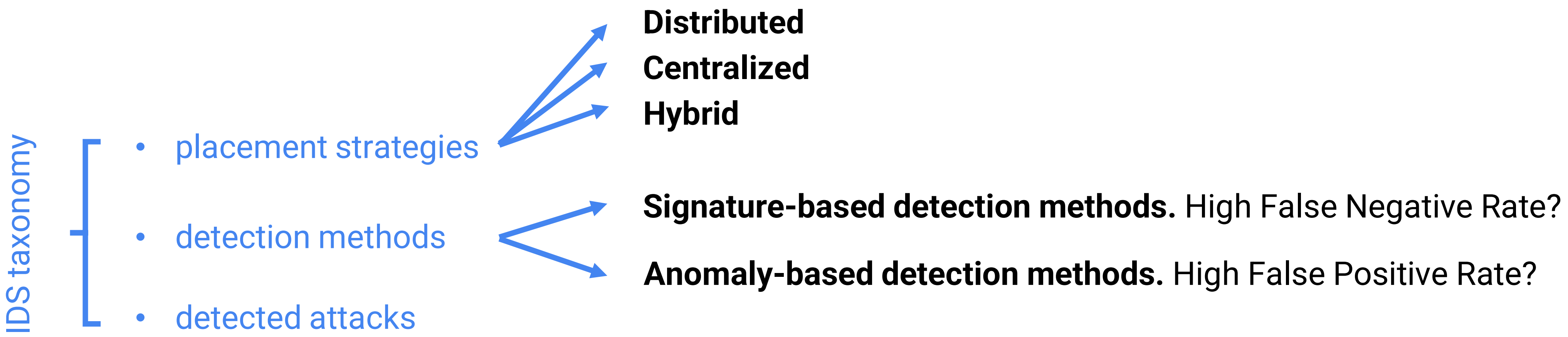
Logs Alarms

HIDS (Host IDS):

- host low resources and OS conformation,
- access to fine data and side channel data.

NIDS (Network IDS):

- effective or furtive network node, in a more powerful device,
- access to addresses, frames type, payload, etc… until cyphered.



IDS taxonomy

- placement strategies
- detection methods
- detected attacks

Distributed

Centralized

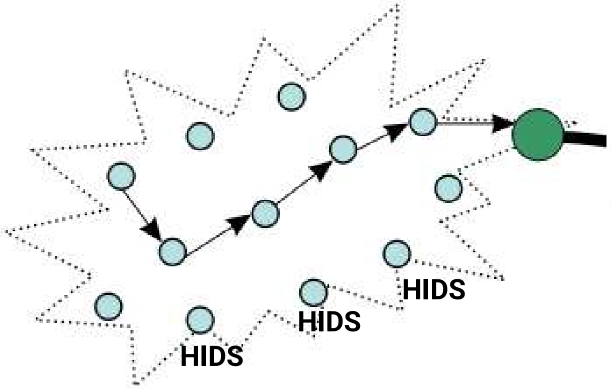
Hybrid

Signature-based detection methods. High False Negative Rate?

Anomaly-based detection methods. High False Positive Rate?

(Zarpelão et al., 2017)

2 - IDS in a nutshell > a few IDS examples

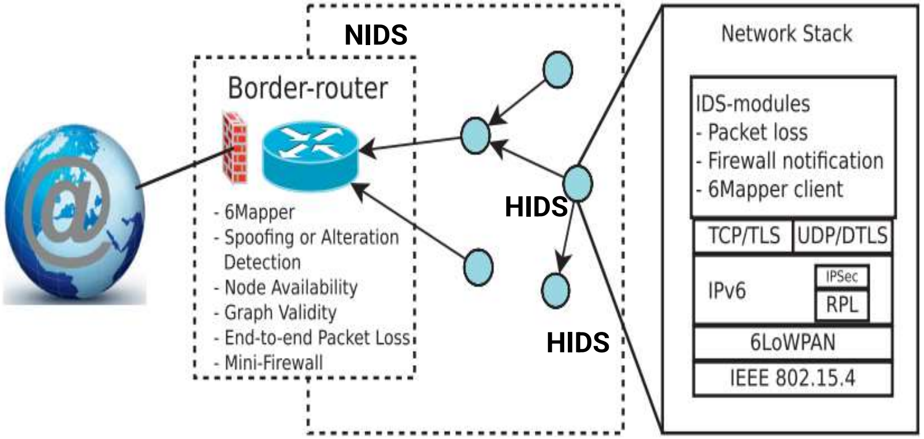


(Lee et al., 2013)

Distributed placement

Anomaly-based detection
Host actual electrical consumption is compared to a modelized consumption.

Detected attacks
DoS attacks in 6LoWPAN contexts.

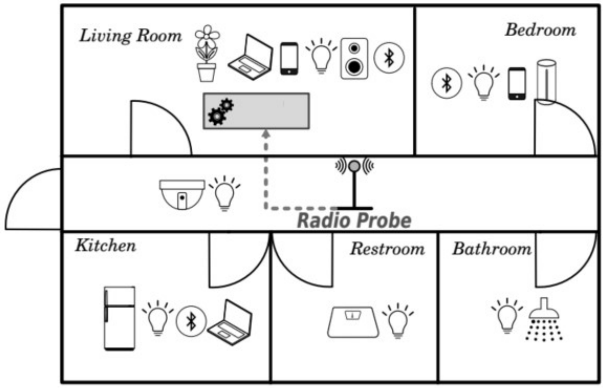


(Raza et al., 2013)

Hybrid placement
HIDSs cooperate with the NIDS to elaborate a network graph used in intrusion detection.

Hybrid detection (signature & anomaly)

Detected attacks
Routing attacks in 6LoWPAN contexts.



(Roux et al., 2018)

Centralized placement, furtive NIDS

Anomaly-based detection
RSSI* captured by radio probe feeds an autoencoder neural network previously trained with normal situations.

Detected attacks
Several, in several protocol stacks.

**Received Signal Strength Indication*

3 – Characteristics of a smart-home IDS

Many IDS papers do not address protocol stacks heterogeneity (neither cost nor user profile)

A few papers started addressing it: (Siby et al., 2017), (Roux et al., 2018), (Anantharaman et al., 2020), (Tournier et al., 2020)

Requirements of a smart-home protection solution:

- coverage of most popular technologies and new ones,
- adapted cost (<100 €),
- standalone in already deployed sites, simple for users.

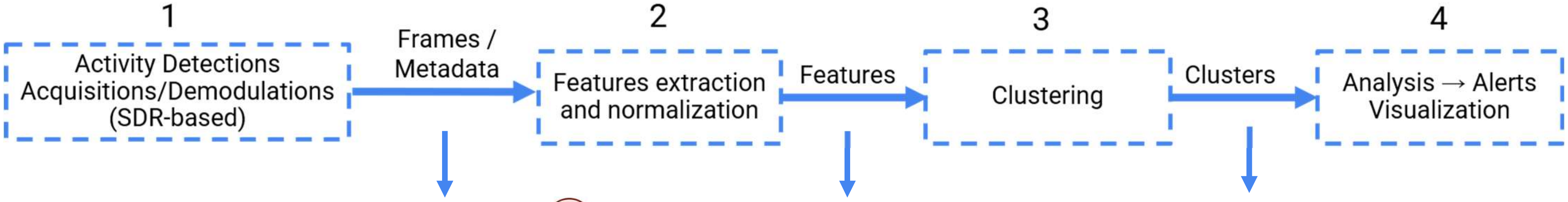
Requirements
x
IDS taxonomy

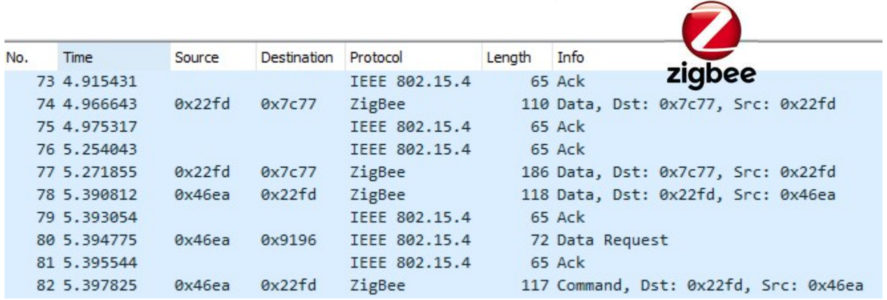
- centralized NIDS with medium resources, updatable,
- anomaly-based, cheap unsupervised ML algo,
- agnostic, passive, autonomous,
- polyvalent architecture thanks to agnostic SDR* probe(s),
- alerts performed by relevant smartphone notifications.

Software-Defined Radio

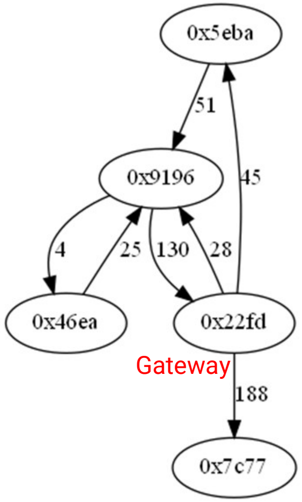
3 – Proposed architecture for a smart-home IDS

A « passive, low-cost and easy to use multi-stack centralized IDS »

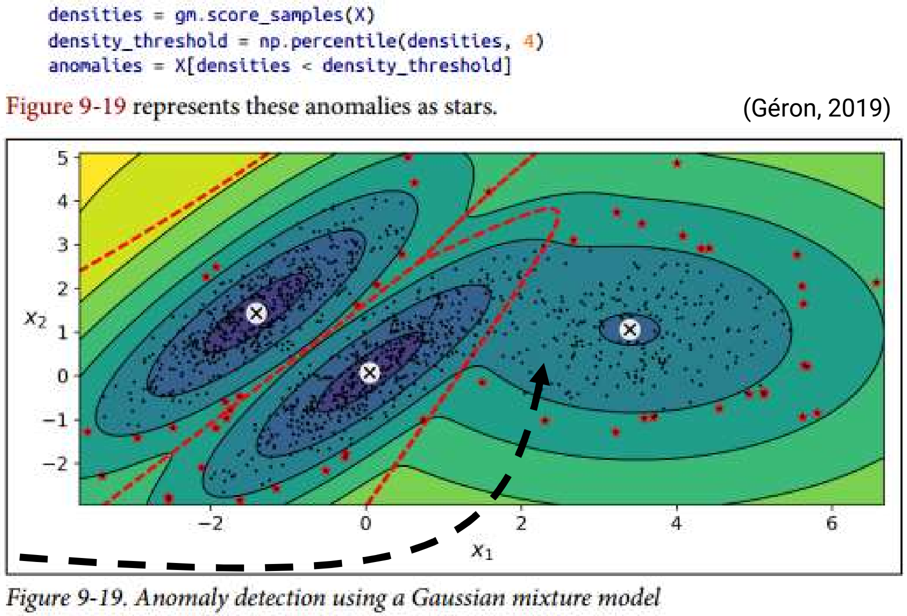




No.	Time	Source	Destination	Protocol	Length	Info
73	4.915431			IEEE 802.15.4	65	Ack
74	4.966643	0x22fd	0x7c77	ZigBee	110	Data, Dst: 0x7c77, Src: 0x22fd
75	4.975317			IEEE 802.15.4	65	Ack
76	5.254043			IEEE 802.15.4	65	Ack
77	5.271855	0x22fd	0x7c77	ZigBee	186	Data, Dst: 0x7c77, Src: 0x22fd
78	5.390812	0x46ea	0x22fd	ZigBee	118	Data, Dst: 0x22fd, Src: 0x46ea
79	5.393054			IEEE 802.15.4	65	Ack
80	5.394775	0x46ea	0x9196	IEEE 802.15.4	72	Data Request
81	5.395544			IEEE 802.15.4	65	Ack
82	5.397825	0x46ea	0x22fd	ZigBee	117	Command, Dst: 0x22fd, Src: 0x46ea



60-second graph w./ number of frames between nodes



```
densities = gm.score_samples(X)
density_threshold = np.percentile(densities, 4)
anomalies = X[densities < density_threshold]
```

Figure 9-19 represents these anomalies as stars.

Figure 9-19. Anomaly detection using a Gaussian mixture model

(Géron, 2019)

Conclusion

Contribution

- a smart-home IDS design based on smart-home ecosystem characteristics: tech., economical, human.

Open questions

- radio conditions: signal strength, coverage, etc. : number/localization of probes ?
- dimensionality of data/graphs.

Roadmap

- end up workflow for Zigbee (to date: steps 1 & 2 of architecture are completed),
- assess workflow relevance with malware datasets or real attacks,
- support another protocol stack → successful POC of an IDS to be adopted in smart home contexts.

Thank you for your attention.

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