ITU-SUDACAD Regional Forum on Internet of Things for Development of Smart and Sustainable Cities

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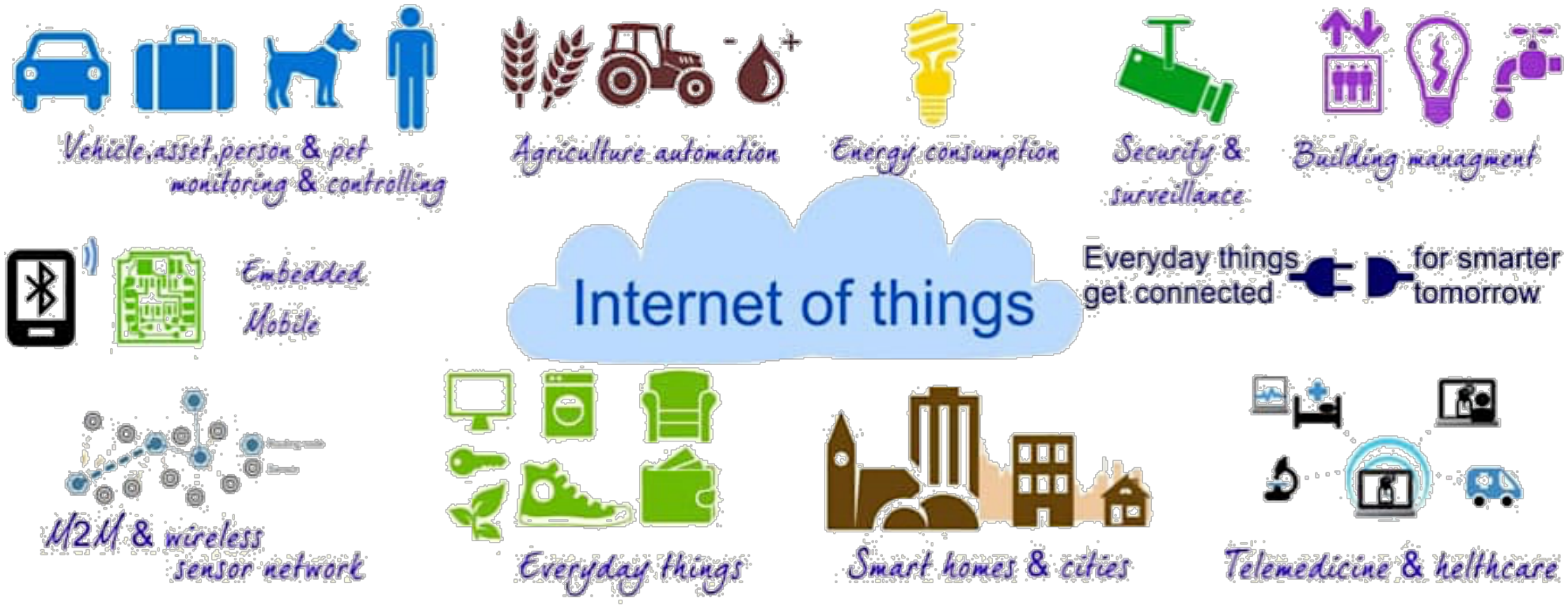
Privacy and trust in IoT

Gopi Garge

Agenda

- The context of SSC
- Trust & Privacy – Some thoughts
- Technology for Trust?
- Privacy
- Conclusion

Enablers of SSC



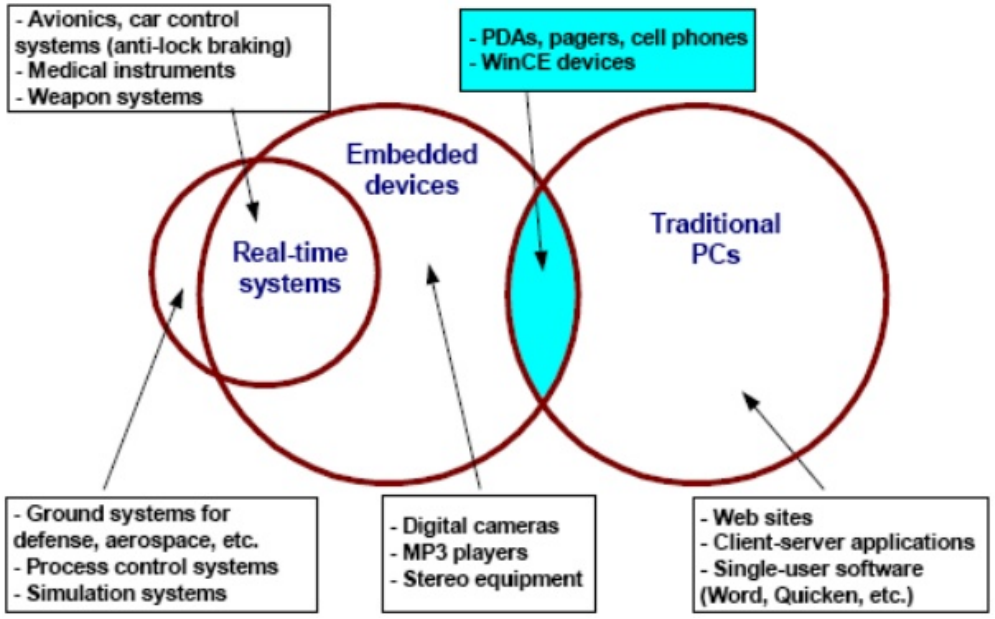
Source: https://disruptionhub.com/wp-content/uploads/2014/11/internet-of-things.jpg

SSC evolves into

Source: http://www.embedded-computing.com/embedded-computing-design/security-for-iiot-embedded-devices-a-platform-based-approach#

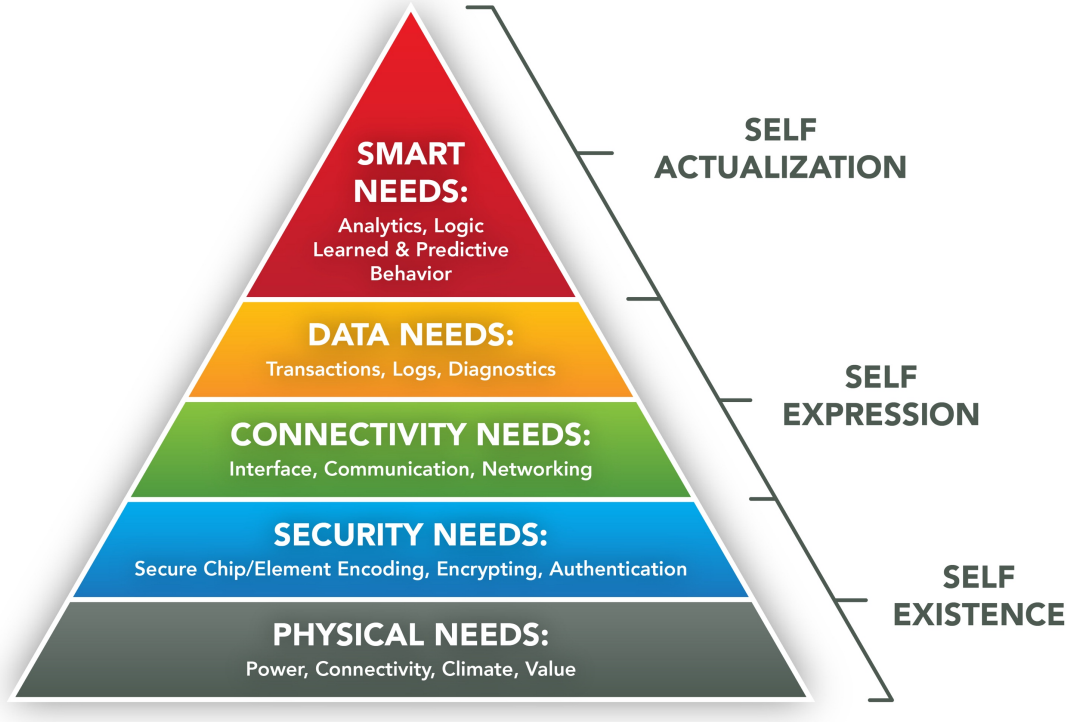
The SSC Context

- Interconnectivity
  - Layered and complex
- Devices
  - Wide variety of capabilities and application contexts
  - Independently powered, Embedded, Autonomous
- Networks
  - Dense at the edge
  - Converging traffic towards gateways
  - Substantially wireless; Guaranteed delivery?
  - Infrastructure
    - Single network, multiple services? (SoA, SDN, ..?)
    - Single backbone, multiple edge networks?
    - Multiple networks?



The SSC Context - 2

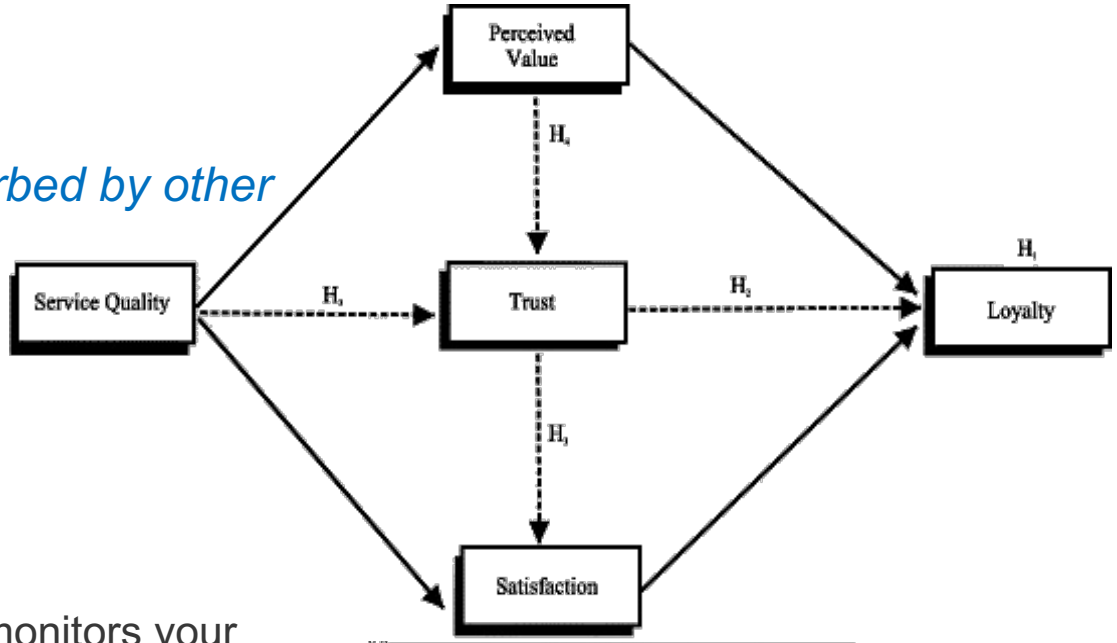
- Data Generated
  - Volumes, storage, archives
  - Ownership
  - Sharing, Open data
- Services
  - Interactions between services
    - For data exchange
    - For information extraction
  - Common point of service delivery
    - Each service with a different app? NO!
    - Multiple authentications? NO
- How would arbitration work?

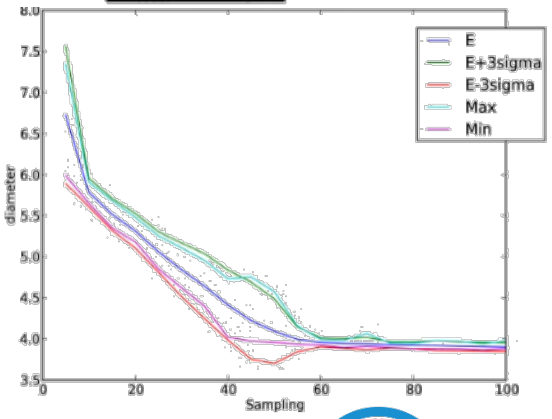


Source: https://techcrunch.com/2015/09/05/the-hierarchy-of-iot-thing-needs/

Trust and Privacy

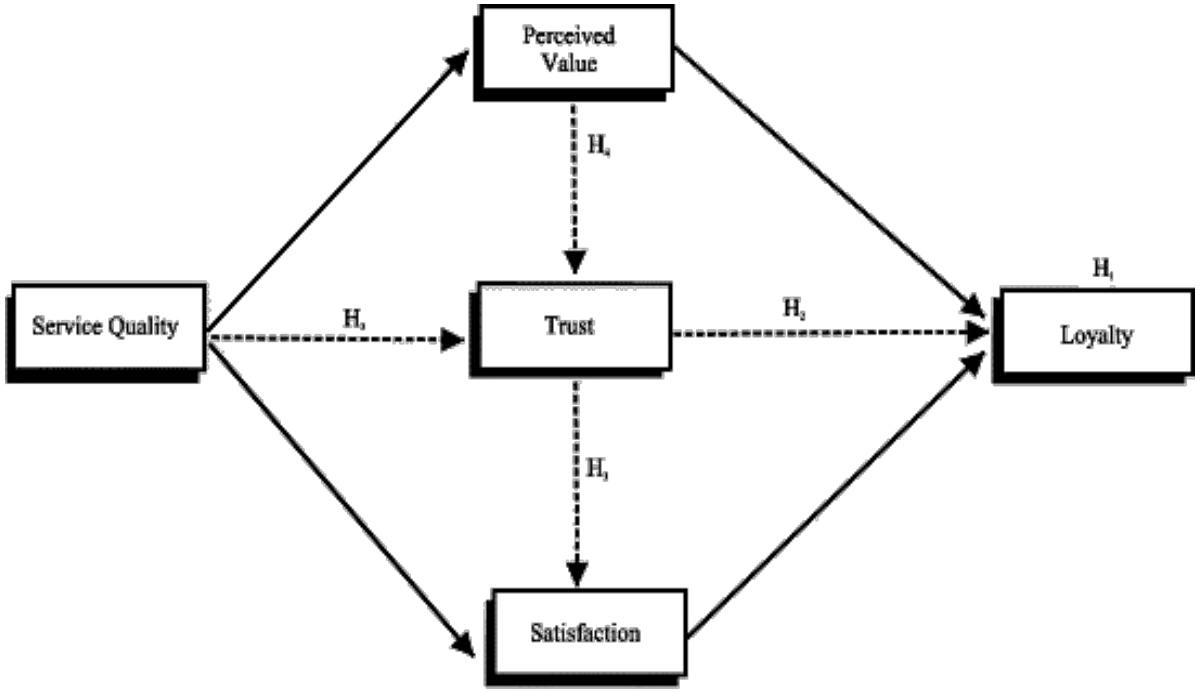
- Privacy – "*a state in which one is not observed or disturbed by other people; the state of being free from public attention*"
  - Data
  - Information
  - Individual
- Data
  - Who owns it? Users?
  - Is it shared? Who authorizes it?
  - Eg: The highways authority monitoring traffic effectively monitors your movement!
- Trust - *firm belief in the reliability, truth, or ability of someone or something*
  - Devices – their presence and location, the data they generate, their functions and interaction
- Levels of Trust?
- Trust Networks? Is a zero trust architecture feasible?

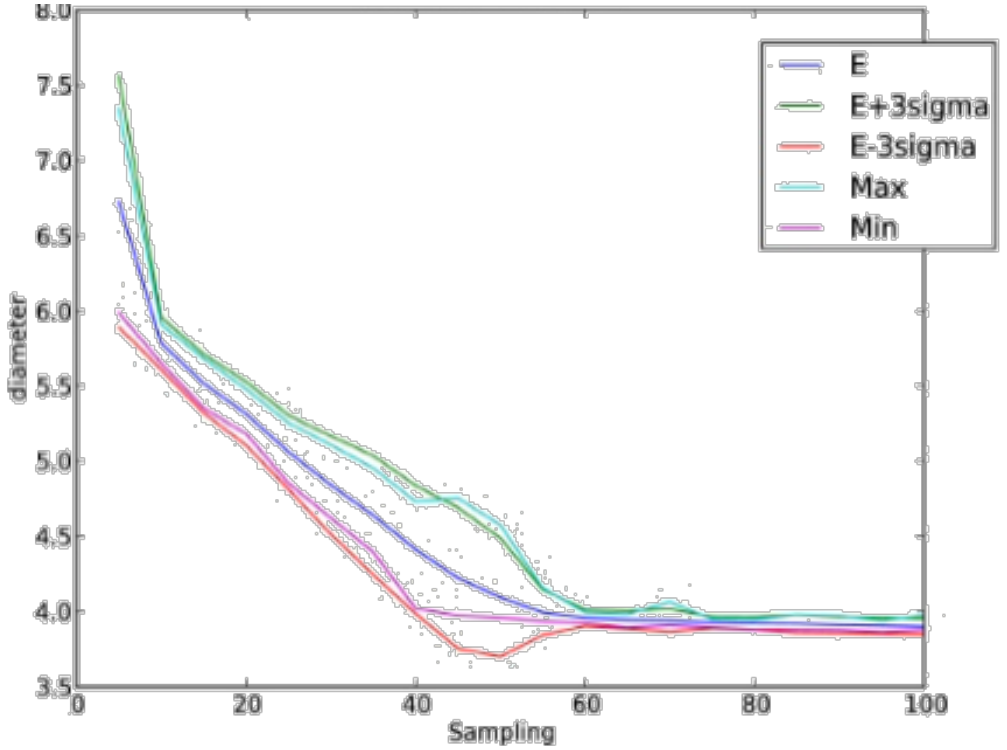




Source: Harris, L.C. and Goode, M.M., 2004. The four levels of loyalty and the pivotal role of trust: a study of online service dynamics. *Journal of retailing*, *80*(2), pp.139-158.

Trust & Privacy



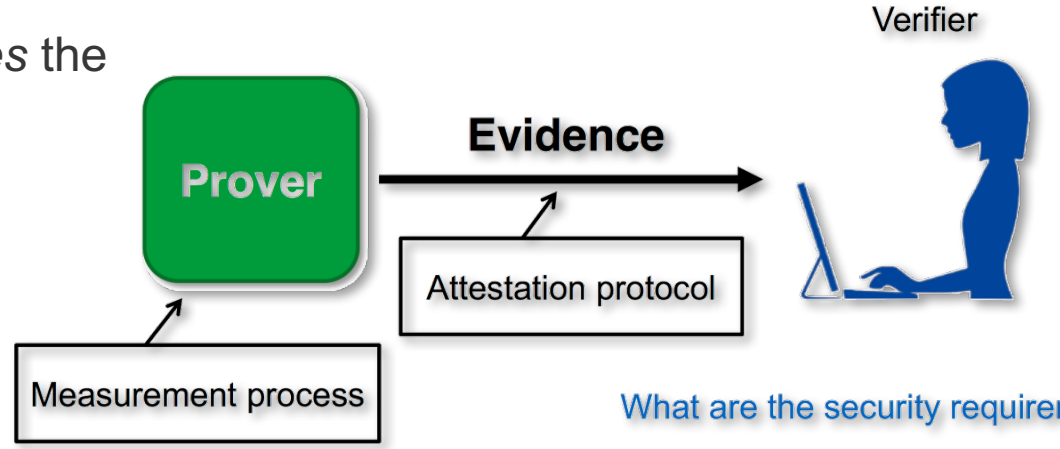


Source: konegis@uni-koblenz.de

There is a lot of housekeeping required. How will it be done? Centralised or Distributed?

Trust

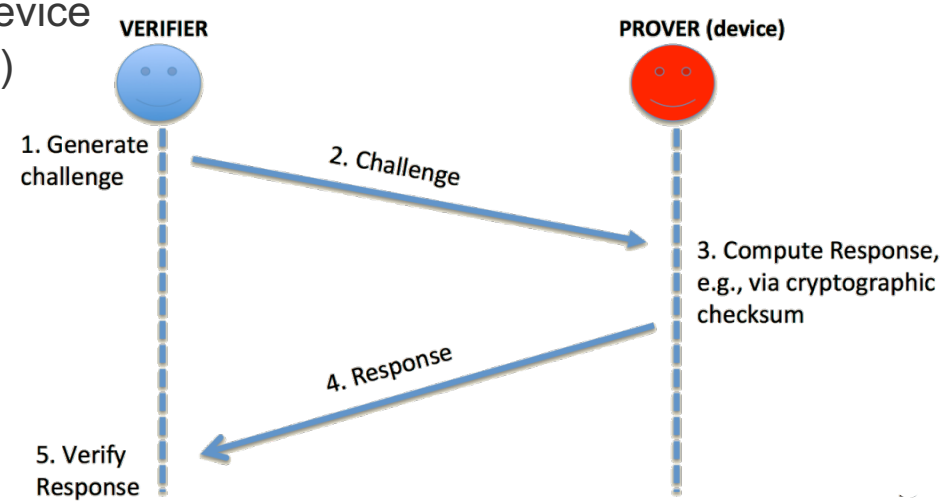
- Number of IoT devices *broadens and amplifies* the attack surface
  - Network
  - Software
  - Physical
- Are the devices trustworthy?
  - Do they behave as expected?
  - Are they in specific states - pre-defined/well-known states?
- Remote attestation is used for verifying states
  - Authenticate the hardware and software to a remote server



What are the security requirements?

Remote Attestation

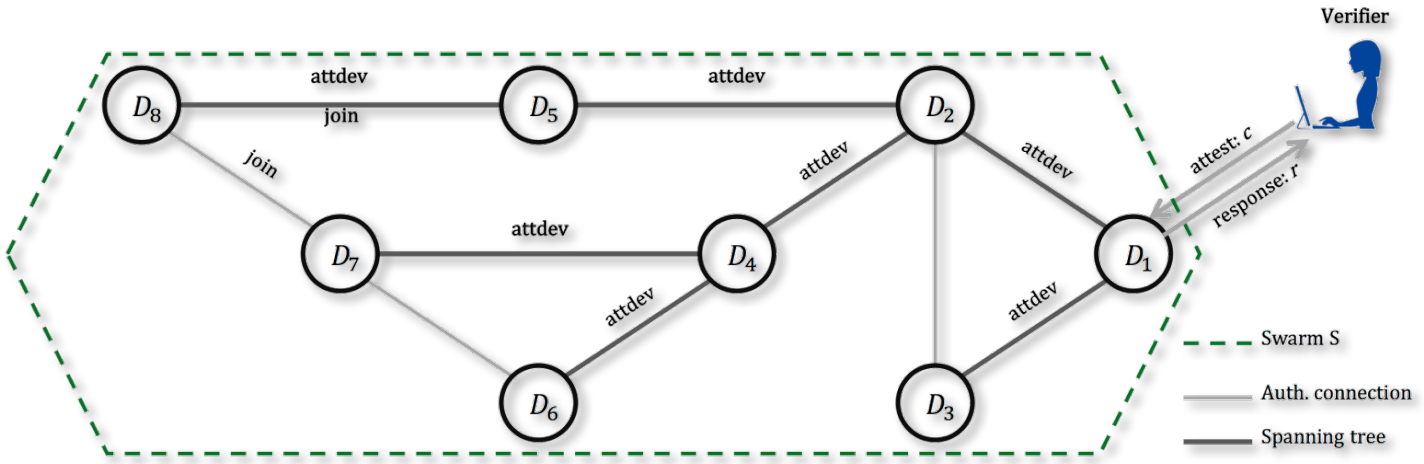
- Remote Attestation - *2-party security protocol between trusted Verifier and untrusted Prover*
  - Prover – **untrusted** (possibly compromised/infected) embedded device
  - Verifier–**trusted** reader/controller/base-station (not always present)
  - Internal state of Prover composed of:
    - Code, Registers, Data Memory (RAM), I/O, etc.
- Attestation requires:
  - Authenticity – representing the real state of the system
  - Freshness – represent the current state
- Types
  - Hardware – Trusted Platform Module (TPM)
  - Software – computes a time-optimal checksum of the verifier; “time” is limiting!
  - Hybrid



Source: gene.tsudik@ucl.edu

Implementation?

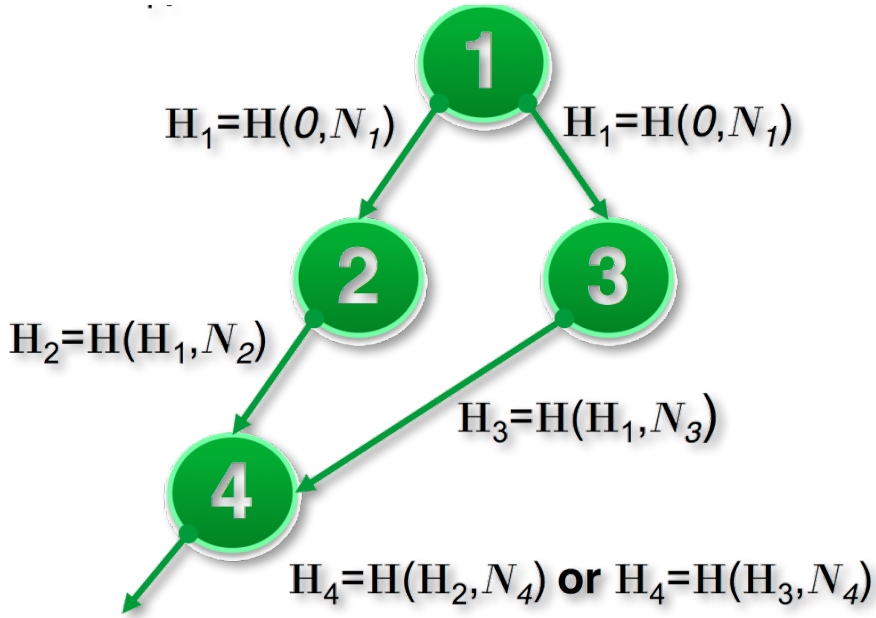
- Attestation protocols assume a single prover
  - IoT scenarios involve groups of devices (swarms) as provers
- Groups / Swarms
  - Devices can move within groups – varying topology
  - Devices can join or leave the group – dynamic membership
- SEDA: Scalable Embedded Device Attestation



Source: Asokan, N., Brasser, F., Ibrahim, A., Sadeghi, A.R., Schunter, M., Tsudik, G. and Wachsmann, C., 2015, October. Seda: Scalable embedded device attestation. In *Proceedings of the 22nd ACM SIGSAC Conference on Computer and Communications Security* (pp. 964-975). ACM.

Attestation

- Attestation schemes, currently
  - Improve security, performance and functionality
- Attestation measures binaries at load time
- Run-time attacks are not addressed
  - Control-flow attestation (C-FLAT)
  - Handles control loops too
- Property based attestation



Source: Abera, T., Asokan, N., Davi, L., Ekberg, J.E., Nyman, T., Paverd, A., Sadeghi, A.R. and Tsudik, G., 2016, October. C-FLAT: control-flow attestation for embedded systems software. In *Proceedings of the 2016 ACM SIGSAC Conference on Computer and Communications Security* (pp. 743-754). ACM.

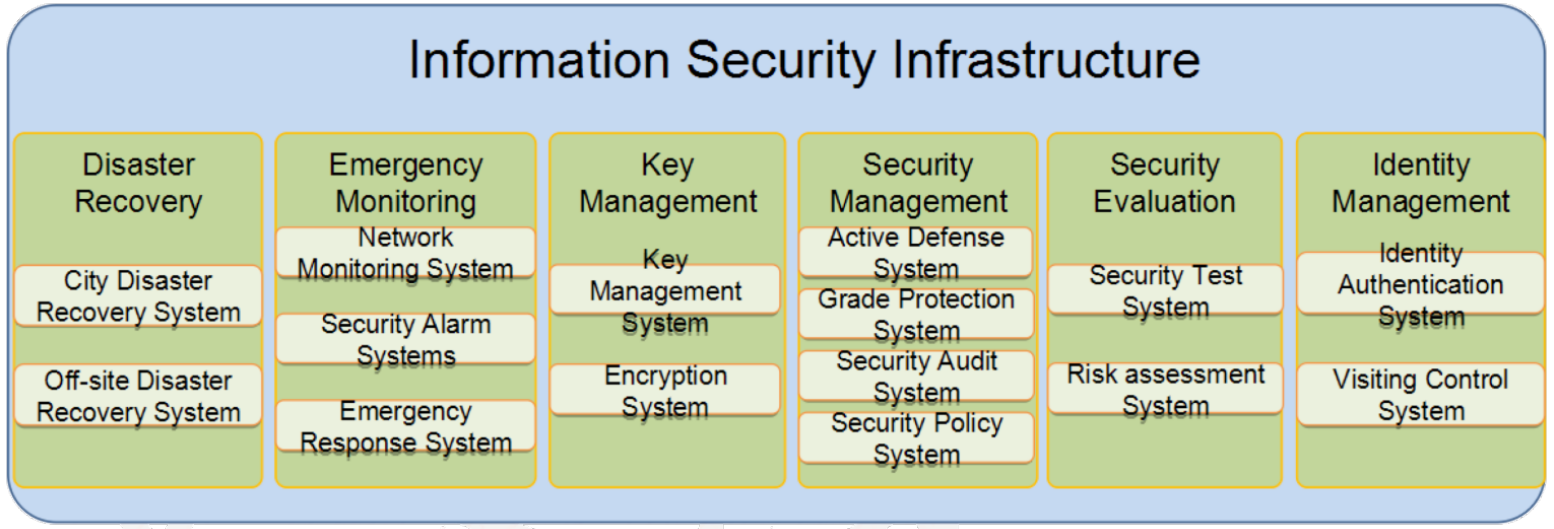
Privacy

- Privacy forms are highly inter-related
  - identity privacy (to protect personal and confidential data);
  - bodily privacy (to protect the integrity of the physical person);
  - territorial privacy (to protect personal space, objects and property);
  - locational and movement privacy (to protect against the tracking of spatial behaviour);
  - communications privacy (to protect against the surveillance of conversations and correspondence); and
  - transactions privacy (to protect against monitoring of queries/searches, purchases, and other exchanges).
- IoT and SSC touch all of these!

Kitchin, R. (2016) Getting smarter about smart cities: Improving data privacy and data security. Data Protection Unit, Department of the Taoiseach, Dublin, Ireland

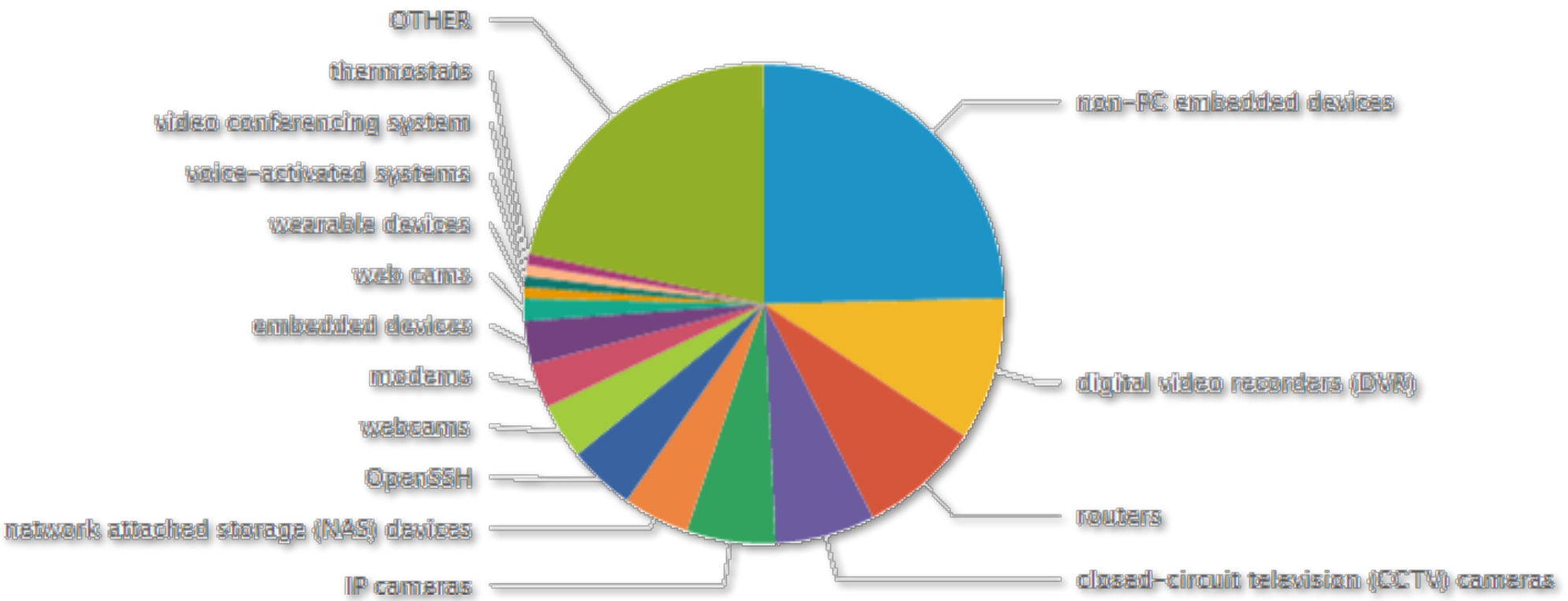
Privacy

- Data privacy
  - Fairly well addressed in the context of storage and data transport
- Information privacy
  - Connotations not fully understood in the context of IoT/SSC; easy to derive behavioural patterns
  - Several personal spaces would have personal information stored on devices
  - Seclude from public scrutiny
- Legislation



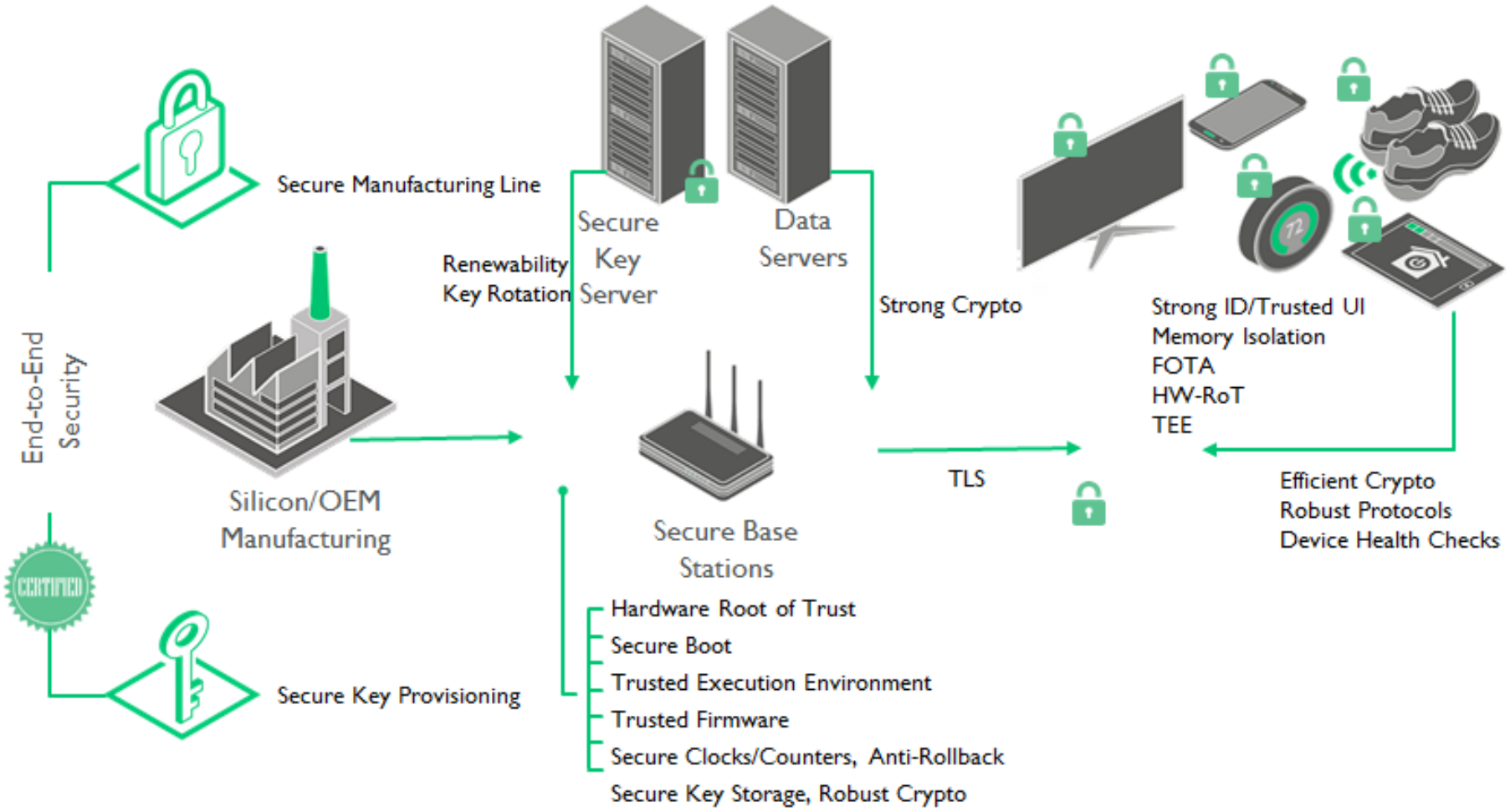
Source: FG-SSC "Technical Report on Cyber-Security, Data Protection and Cyber-Resilience in Smart Sustaintable Cities", page 16

Attack Targets



Source: https://blog.surfwatchlabs.com/2017/03/24/webinar-iot-devices-expanding-digital-footprints-security-issues/

Pervasive Security?



Source: https://community.arm.com/iot/embedded/b/embedded-blog/posts/securing-the-embedded-iot-world

The need for enforcement policies

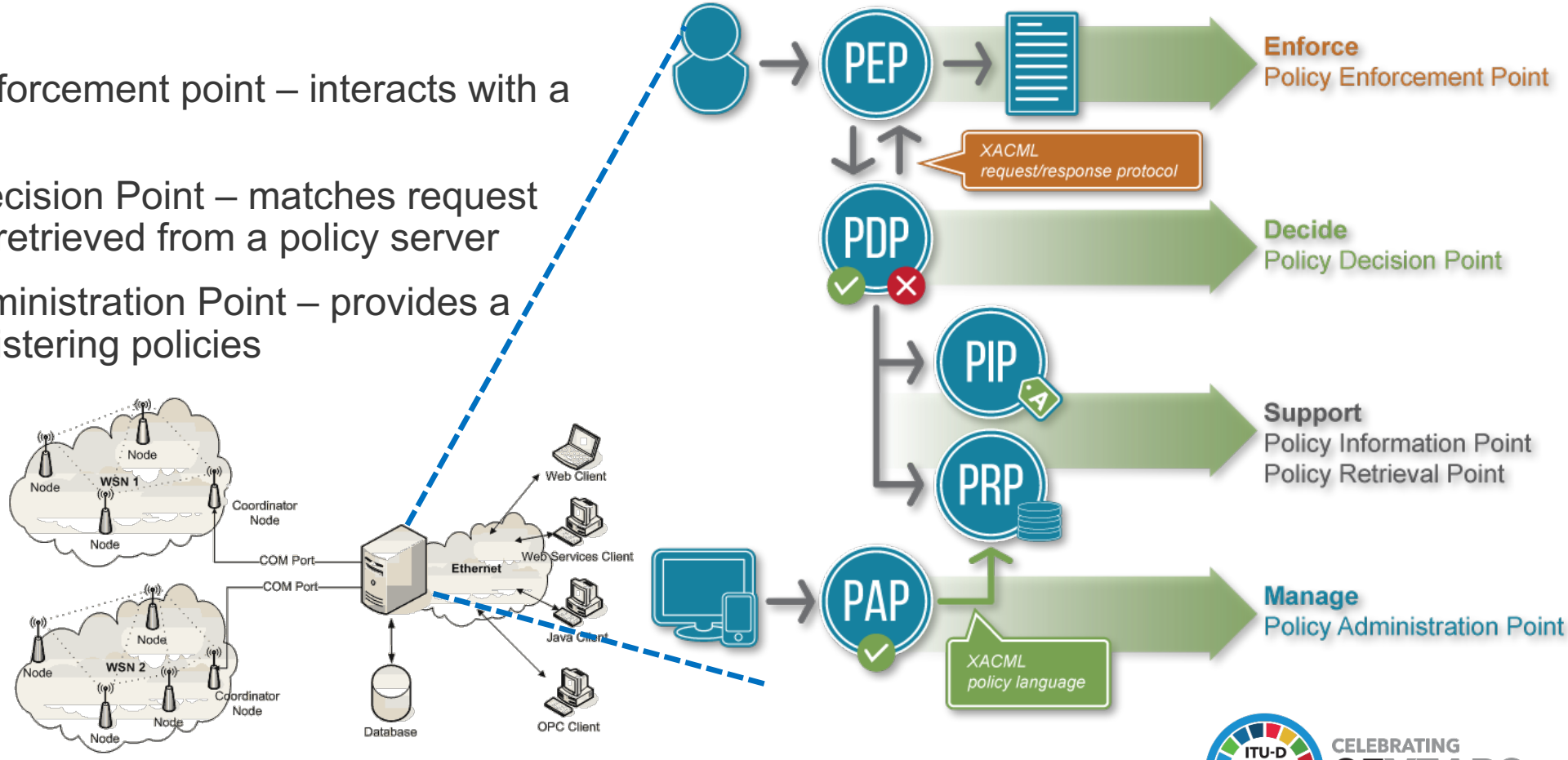
Policies, in general

- Policy - *a course or principle of action adopted or proposed by an organization or individual*
  - Designed, not just conceived
  - Often, determined by events
  - Policy effects must be direct and immediate – not all should be long-term
- Usually, bottom up
- Evolutionary process
- Asset/system analysis must not be extended to sectors and jurisdictions

Source: Australian Government Protective Security Policy https://www.protectivesecurity.gov.au/overarching-guidance/Pages/default.aspx

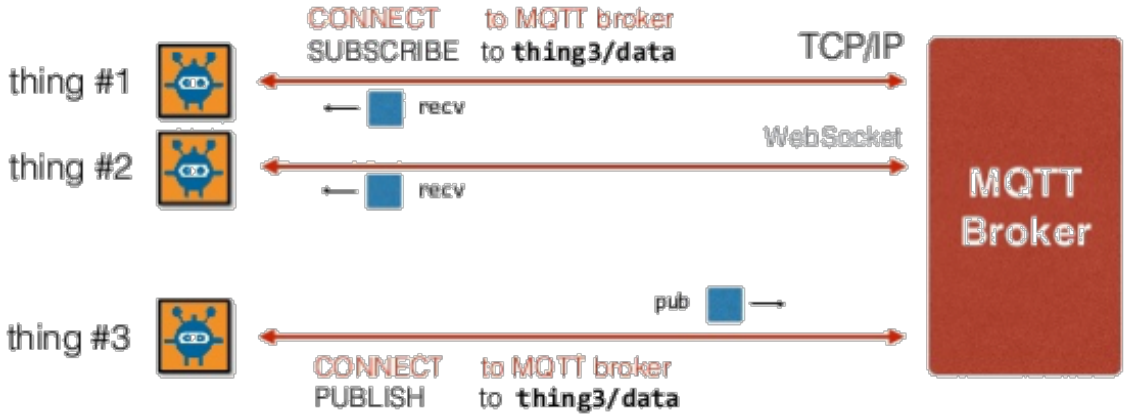
Policy Enforcement

- PEP – Policy enforcement point – interacts with a request, Y/n
- PDP – Policy Decision Point – matches request with policy data retrieved from a policy server
- PAP - Policy Administration Point – provides a means of administering policies

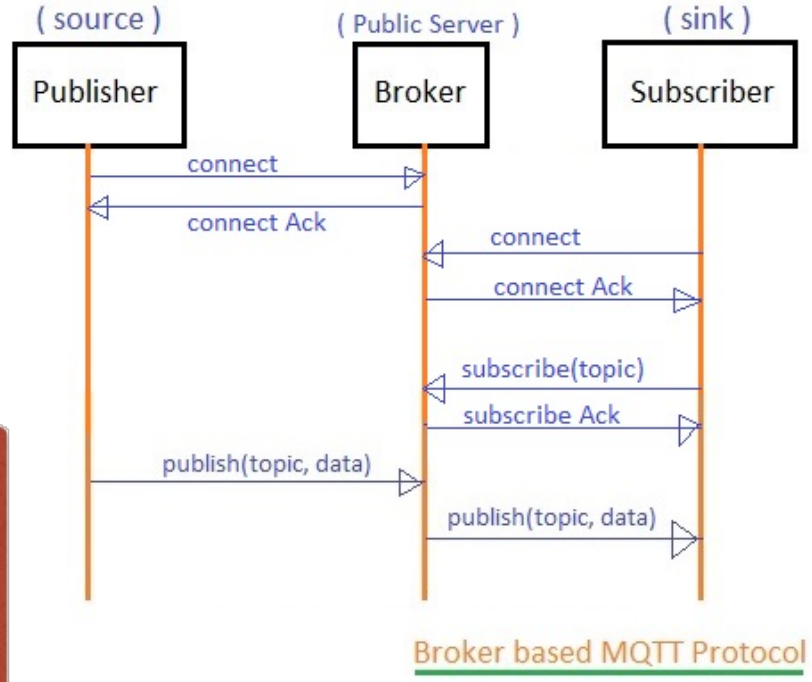


Policy Enforcement

- Working protocol is MQTT
- Publish, subscribe features
- Requires additional support for policy enforcement
- Middleware option ? SecKit[1], NOS v1, NOS[2] v2



Source: https://www.slideshare.net/BryanBoyd/mqtt-austin-api



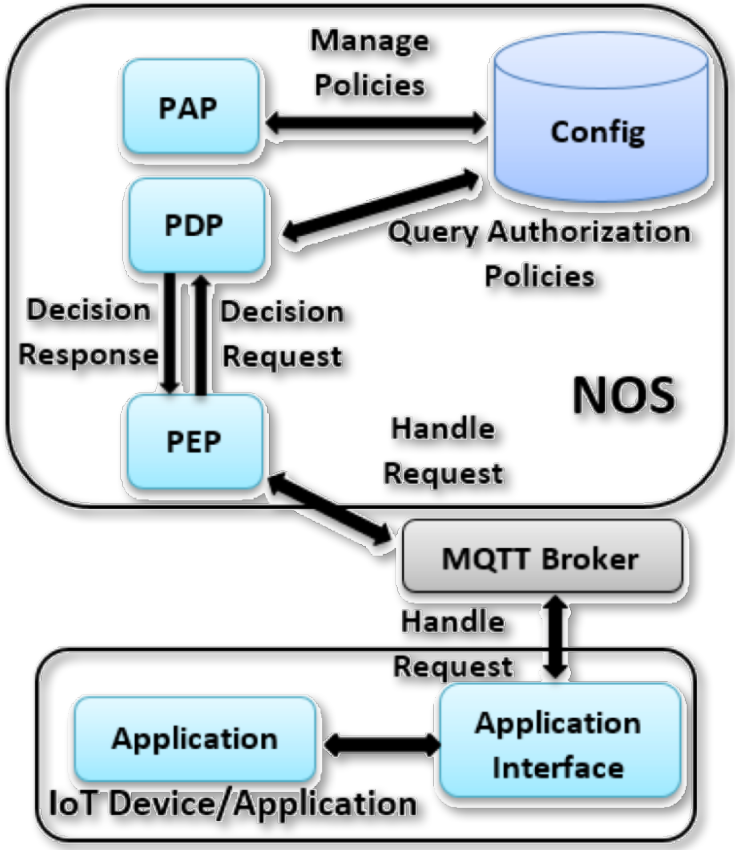
Source: rf-wirelessworld.com

1 - Neisse, R., Steri, G. and Baldini, G., 2014, October. Enforcement of security policy rules for the internet of things. In *Wireless and Mobile Computing, Networking and Communications (WiMob), 2014 IEEE 10th International Conference on* (pp. 165-172). IEEE.

2 - Sicari, S., Rizzardi, A., Miorandi, D. and Coen-Porisini, A., 2017. Dynamic Policies in Internet of Things: Enforcement and Synchronization. *IEEE Internet of Things Journal*.

Policy Enforcement

- Networked Smart Objects (NOS) – middleware on gateways
- Monitor more than data and health of device
  - enforcement when a message is delivered to a client in addition to enforcement when a client subscribes to a topic;
  - support for reactive rules to notify, log, or request user consent;
  - misbehavior checking rules, for Denial-of-Service (DoS) attack detection.
  - modification of messages and identity obfuscation in addition to simply allow or deny;
  - delaying of messages to prevent real-time tracking of devices and users;
  - Multiple NOSs communicate and synchronise – topic creation, policy updates. Leader election among the group of gateways for periodical change.



Questions…

- How will such enforcement scale across the infrastructure?
  - Distributed approach? Policy synchronisation, context dependency (entry into campus vs. entry into a lab), Size of the policy dB, Performance – with actuation, ….
- How vulnerable will the PEPs be?
- Enforcement on a common infrastructure?
- Policy administration?
- Policy design?

References

Kitchin, R. (2016) Getting smarter about smart cities: Improving data privacy and data security. Data Protection Unit, Department of the Taoiseach, Dublin, Ireland.

Minelli, M., Chambers, M. and Dhiraj, A. (2013) Big Data, Big Analytics. Wiley, Hoboken, NJ

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Thank You