A Cost-efficient Building Automation Security Testbed for Educational Purposes

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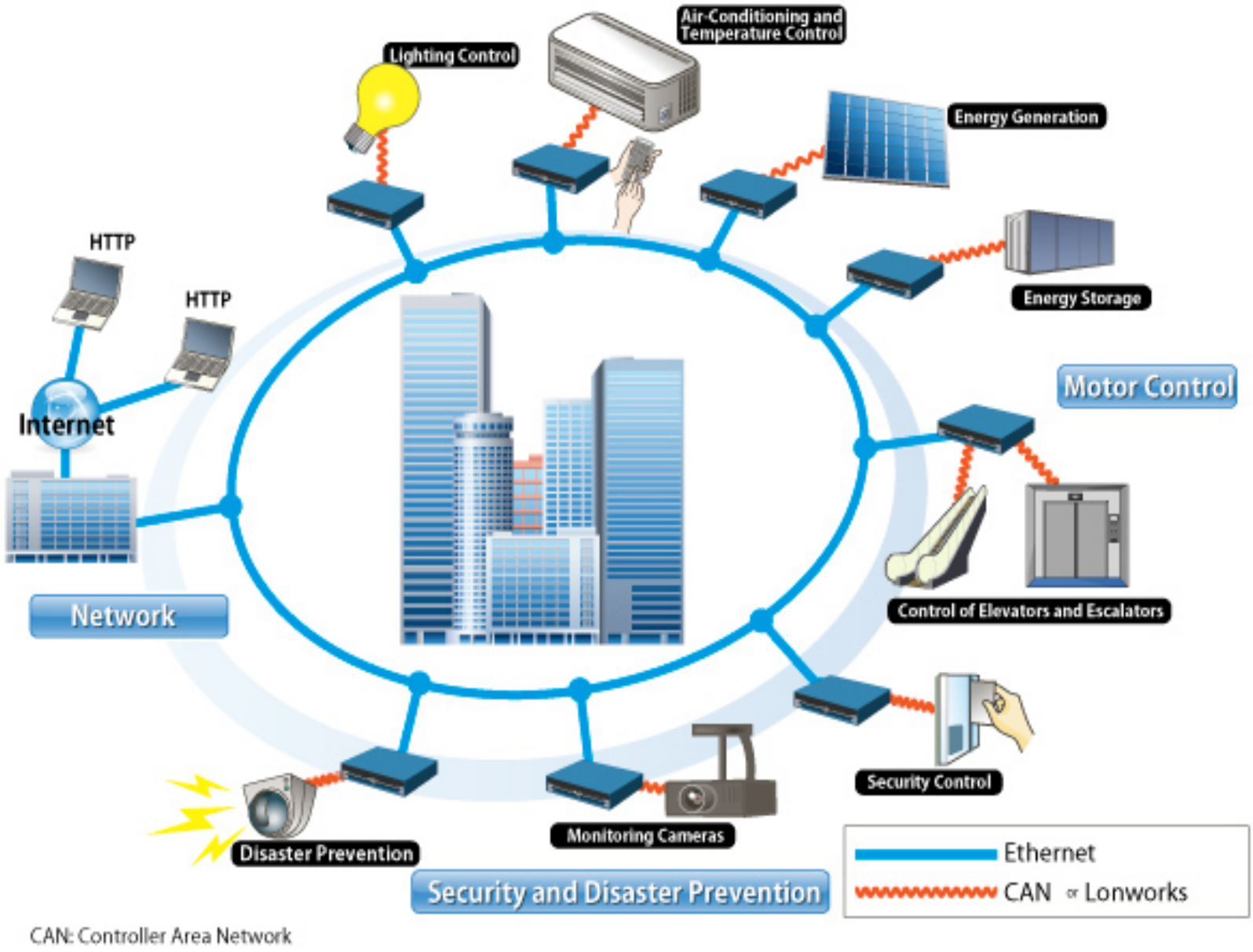
Outline

- Building Automation Systems
- Security threats in BAS
- Covert Channels in BAS
- State of security research in BAS
- Virtual testbed description
- Testbed Setup
- Benefits of Virtual Testbed

Building Automation Systems

- Building automation systems (BAS) are concerned with the control, monitoring and management of services such as heating, ventilation and lighting in buildings
- Main aim of BAS is to meet the following goals:
  - provide safety for inhabitants (e.g. by integrating fire alarm systems or physical access control)
  - control the climate in the building/supervise and control the heating, ventilation, and air conditioning equipment
  - perform facility management (indicate problem by generating reports, graphs and annunciating alarms)
  - perform energy management strategies to reduce operating and energy costs



Source:http://www.renesas.eu/edge_ol/feature/07/index.jsp

Security Threats in BAS

- **Current security threats according to Kastner et al.**:
  - Network Attacks:
    - Attack on the network medium to access the exchanged data
    - Manipulation, fabrication or interruption in the transmitted data
  - Device Attacks:
    - On Software Level: code injection, exploiting algorithm
    - On Physical Level: component replacement

- **Emerging security threats**:
  - Covert channels and data leakage

Covert Channels in BAS

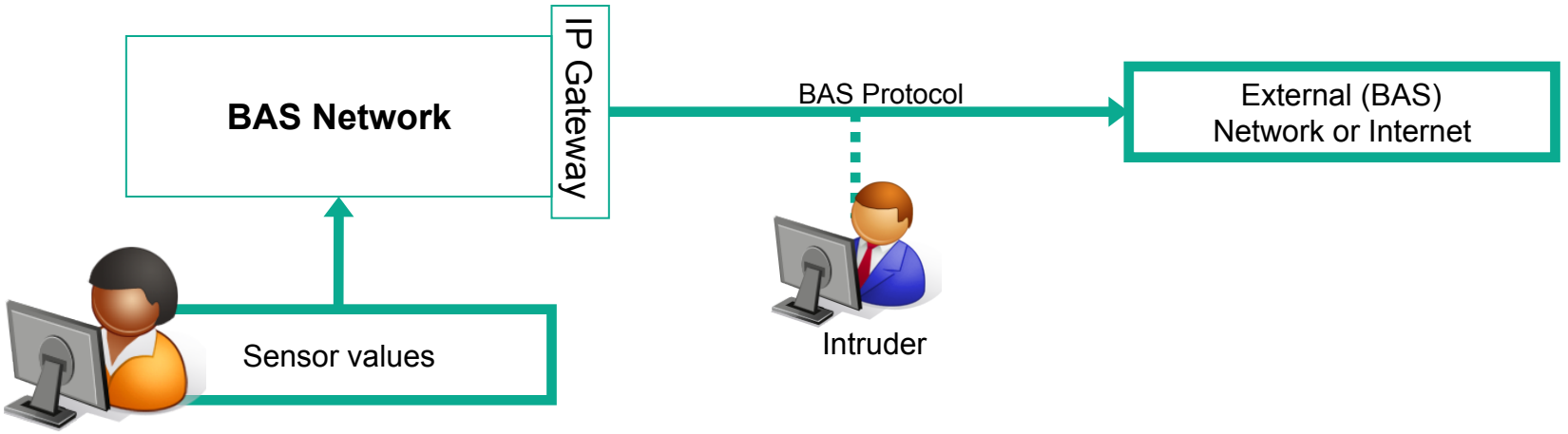
- They are used to transfer secret information in a *stealthy* manner and aim on hiding the fact that communication is taking place.

In terms of building automation systems, covert channels:

- Are one of the emerging threats in BAS.
- Realize data exfiltration over the BAS network in order to bypass sophisticated commercially available data leakage protection (DLP) means, which do not foresee data leakage protection in BAS protocols.
- Allows bypassing BAS internal protection means with policy breaking communication flows (e.g., for the undesired observation of sensor values).

Data Leakage through BAS

- (Un)intentional data leakage using remote connection of a BAS
  - via **network covert channel**
- Connection used for legitimate purpose (administration of remote buildings)



Source: Wendzel, S., Kahler, B., Rist, T.: Covert Channels And Their Prevention In Building Automation Protocols: A Prototype Exemplified Using BACnet, Proc. CPSCom, IEEE, 2012.

Remote access to the sensor data

- Monitoring the sensor values and actuator states (temperature, presence, heating levels, …)
- Who in a city with buildings configured with building automation infrastructures goes so often out of their homes?
- When can a break-in attempt to a region be performed at the optimal moment? Where exactly?

Source: Wendzel, S., Zwanger, V., Meier, M., Szlosarczyk, S.: Envisioning Smart Building Botnets, in Proc. Sicherheit, GI, Vienna, 2014.

State of security research in BAS

- Educational organizations such as universities as well as small and medium sized enterprises (SMEs) are required to gain access to BAS hardware and software components for conducting research on BAS
- Time consuming to get familiar with the complicated real-world environment
- Possibility of damaging real hardware or influencing real (or even critical) BAS operations
- Linked to high costs and thus not affordable by many institutions

This work aims on sharing knowledge on the setup of low-cost BAS testbeds for universities and SMEs and educate students and employees in the field of BAS fundamentals and BAS security.

Virtual testbed description

- Allows to perform BAS security research for the *building automation control and network* (BACnet) *protocol* suite.

- Based on a defensive mechanism for eliminating covert channels in BACnet communications, so-called ***Traffic normalization***.
  - A traffic normalizer is integrated into routers that inter-connect BACnet network segments in order to monitor the traffic exchanged between the devices.
  - A normalizer drops or modifies packets containing malicious or incompliant content.
  - A normalizer uses normalization rules as a basis, which enforces the known protocol specification.

Virtual testbed description (contd.)

The principal requirements for virtual testbeds include:

- cost-efficiency,
- availability as open source, and
- easy configurability for various scenarios.

Testbed setup

The major reason of establishing the testbed is for *educational purposes*. The following components are used to fulfill the requirements (see figure below):

- **Linux machines** with the open source **BACnet stack** to act as BACnet devices; these systems are virtual Linux machines,
- a **Linux machine** running Snort with our **Snort BACnet extension** to act as a protecting traffic normalizer,
- our **protocol fuzzer** based on **Scapy**.

Testbed setup (contd.)

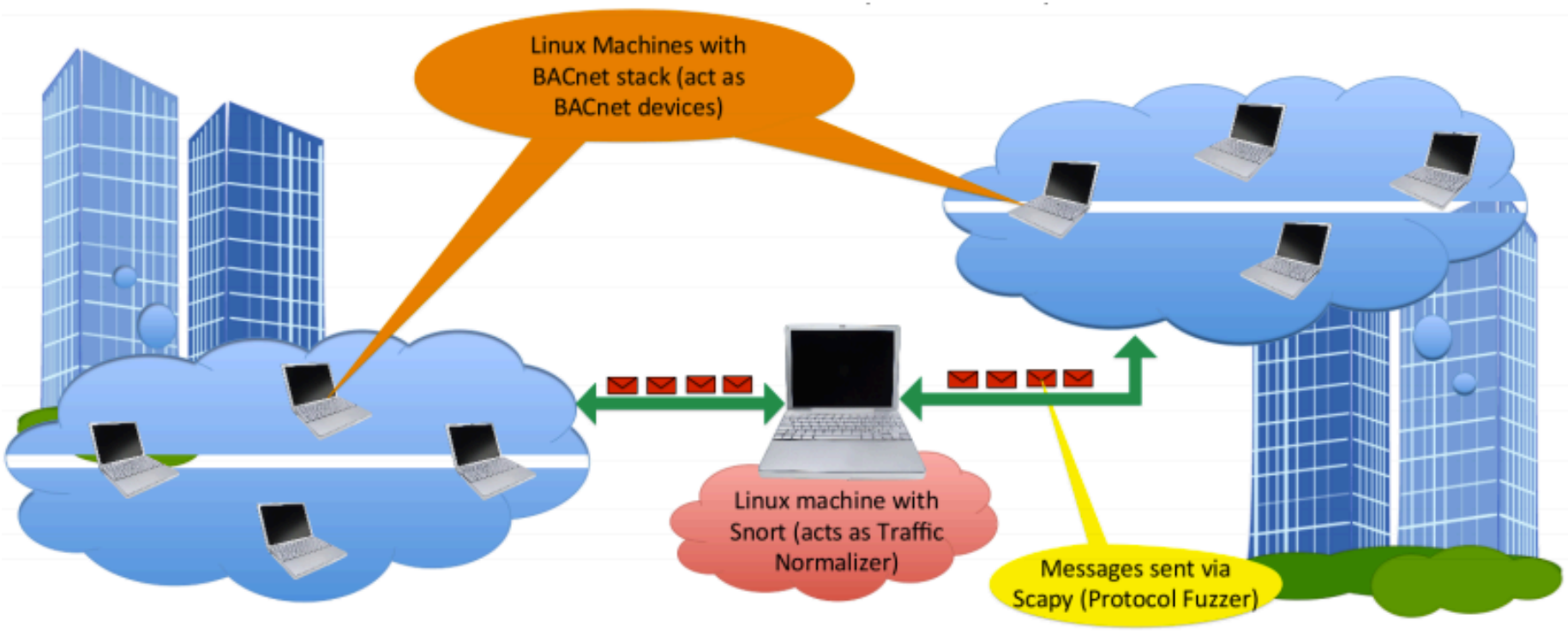
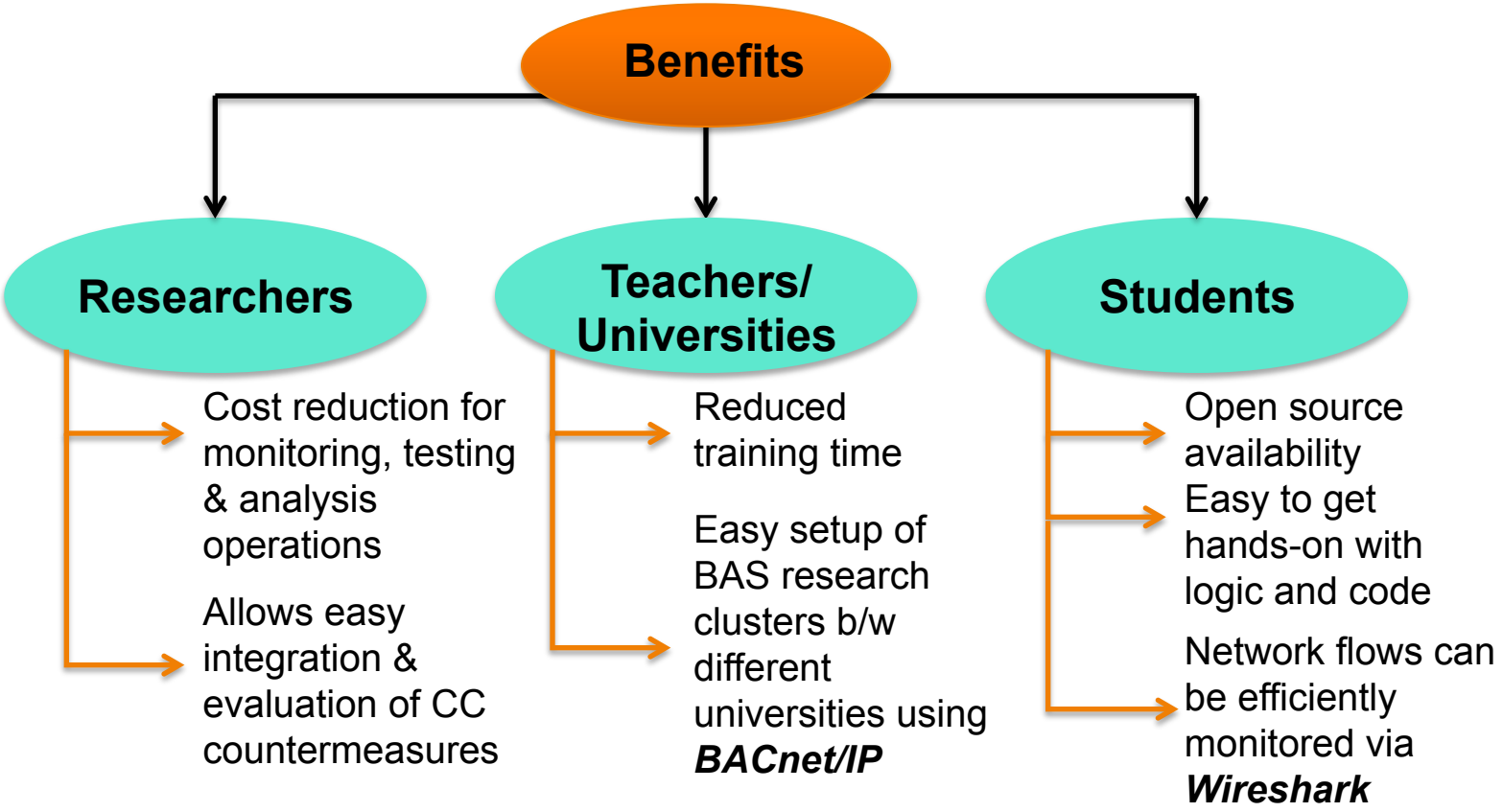


***Figure**. Virtual testbed for BACnet traffic*

Benefits of Virtual Testbed



Thank you for your attention!

Our Expertise:

- Secure Building Automation
- Data Leakage Protection
- Network Steganography/ Network Covert Channels

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