

Proceedings

**5th IEEE European Symposium
on Security and Privacy
Workshops**

EUROS&PW 2020

Proceedings

**5th IEEE European Symposium
on Security and Privacy
Workshops**

7–11 September 2020
Virtual Event



Los Alamitos, California
Washington • Tokyo



All rights reserved.

Copyright and Reprint Permissions: Abstracting is permitted with credit to the source. Libraries may photocopy beyond the limits of US copyright law, for private use of patrons, those articles in this volume that carry a code at the bottom of the first page, provided that the per-copy fee indicated in the code is paid through the Copyright Clearance Center, 222 Rosewood Drive, Danvers, MA 01923.

Other copying, reprint, or republication requests should be addressed to: IEEE Copyrights Manager, IEEE Service Center, 445 Hoes Lane, P.O. Box 133, Piscataway, NJ 08855-1331.

The papers in this book comprise the proceedings of the meeting mentioned on the cover and title page. They reflect the authors' opinions and, in the interests of timely dissemination, are published as presented and without change. Their inclusion in this publication does not necessarily constitute endorsement by the editors, the IEEE Computer Society, or the Institute of Electrical and Electronics Engineers, Inc.

BMS Part Number CFP20N35-ART
ISBN 978-1-7281-8597-2

Additional copies may be ordered from:

IEEE Computer Society
Customer Service Center
10662 Los Vaqueros Circle
P.O. Box 3014
Los Alamitos, CA 90720-1314
Tel: + 1 800 272 6657
Fax: + 1 714 821 4641
<http://computer.org/cspress>
csbooks@computer.org

IEEE Service Center
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
Tel: + 1 732 981 0060
Fax: + 1 732 981 9667
[http://shop.ieee.org/store/
customer-service@ieee.org](http://shop.ieee.org/store/customer-service@ieee.org)

IEEE Computer Society
Asia/Pacific Office
Watanabe Bldg., 1-4-2
Minami-Aoyama
Minato-ku, Tokyo 107-0062
JAPAN
Tel: + 81 3 3408 3118
Fax: + 81 3 3408 3553
tokyo.ofc@computer.org

Individual paper REPRINTS may be ordered at: <reprints@computer.org>

Editorial production by Lisa O'Conner



**IEEE Computer Society
Conference Publishing Services (CPS)**

<http://www.computer.org/cps>

Defensive Programming for Smart Home Cybersecurity

Maria Teresa Rossi*, Renan Greca*[†], Ludovico Iovino*, Giorgio Giacinto[‡] and Antonia Bertolino[†]

* *Gran Sasso Science Institute – L'Aquila, Italy, Email: {firstname.lastname}@gssi.it*

[†] *ISTI - CNR – Pisa, Italy, Email: antonia.bertolino@isti.cnr.it*

[‡] *University of Cagliari – Cagliari, Italy, Email: giacinto@diee.unica.it*

Abstract—Cybersecurity has become a real issue in the development of smart services in the smart home domain, which is formed by a System of Systems where several smart objects are connected to each other and to the Internet. However, these connections expose the devices to possible attackers inside or outside the network, who may exploit software or hardware vulnerabilities to achieve malicious goals. To alleviate this issue, the use of defensive programming assertions can allow the behaviour of smart objects to be monitored and checked for correctness. Furthermore, open source intelligence tools, such as the Shodan search engine, provide features that could be leveraged to detect potential vulnerabilities. In this paper, we propose an approach for the monitoring of Systems of Systems in the smart home domain exploiting the defensive programming paradigm in combination with Shodan APIs.

1. Introduction

Many complex tasks are today handled by *Systems of Systems* (SoS), which are compositions of independent systems that collaborate towards achieving a common task [1], or *mission*. Such a mission goes beyond the goals and capabilities of the individual systems, or *constituents*: indeed the concept of SoS allows for the rapid development of innovative and broad distributed systems in many critical domains [2]. Examples may include: the communication and control of a smart city environment, the safe and intelligent distribution of energy in smart grids, or the immediate response and coordination of IT networks in face of an emergency situation. All these and many other situations rely on the collaboration among a variety of hardware and software modules, and often humans as well, to provide important services to citizens and society. By allowing interconnected physical objects to sense the environment, share data and act accordingly, the Internet of Things (IoT) [3] plays a central role in the diffusion of SoS. In this paper, we focus on IoT-enabled *smart homes*: a facility, usually recently constructed or reformed, that is equipped with special structured networking capabilities enabling occupants to remotely control or program an array of automated home electronic devices [4]. Considering the context of smart homes, security is a crucial concern in order to keep homeowners, as well as their property, safe from intruders and to prevent unwanted behavior of

the connected devices and systems. Indeed, along with enhancing our quality of life, smart homes also increase our risk surface, in particular concerning cybersecurity. If a single constituent system within an SoS is affected by a vulnerability, this can serve as an entry point for the whole network, thus putting the entire SoS at risk of being compromised. Cybersecurity vulnerabilities can have several root causes [5], such as: software, as bugs or design flaws; hardware issues, such as faulty components or sensitivity to certain kinds of interference; unnecessarily open networking ports; inadequate authentication and insufficient access management mechanisms including the use of default or weak passwords; improper patch management; or insufficient audit mechanisms. These vulnerabilities can expose a system to attackers either by allowing them access to the underlying hardware of a specific device, or they can be leveraged to open the access to other systems in the network through default chains of trust. In other words, vulnerabilities create the risk of having the system exposed to any remote attacker over the Internet. As such, it is crucial that vulnerabilities are detected by the system managers as early as possible and measures are taken to properly address them and reduce the risk of compromising the network. Within a smart home environment the connection of all the devices into a network can, on one hand, facilitate communication and control; on the other hand, it can lead to security issues [4]. There are two types of security threats [5], [6]: i) *passive*, when the objective of the attack is only to steal information from the system without affecting it; ii) *active*, when the attack alters the normal functioning of the system. Cyber-attacks are not a new concern to IoT [7], but as IoT devices and connections become a prevalent part of modern life, the safety and security of users must be dealt with upmost importance. The usual CIA triad, Confidentiality, Integrity, and Availability, can be used to categorize IoT attacks. While attacks against availability aim to disrupt the system, attacks against confidentiality and integrity are more subtle, where the attacker breaches the communication channel between two systems in an attempt to intercept messages sent among them, and eventually tamper with them. These kind of attacks can be the stepping stone for attacks with more severe consequences that can bring the SoS in an unsafe state, and undermine its availability. Attacks towards smart homes usually target common devices such as smart refrigerators or other con-

nected electronic devices in order to change their expected behaviour. Typically, attacks targeting IoT devices may expose data in real-time with the intent of intercepting communications between devices, allowing the attacker to steal data or trigger malfunctions. For instance, *smart meters* provide real-time data on electricity and gas usage, enabling optimizations of energy consumption and distribution, and empowering consumers to make intelligent decisions about their energy usage. If smart meters are used in the context of an SoS, e.g., by activating other devices when the consumption is under a certain level, an attack can contribute to an erroneous activation and thus excessive or unnecessary energy consumption, as minor damage. If this erroneous behaviour is detected immediately, the user can take actions and correct the behaviour of the affected devices. Moreover, in all cases in which the possible erroneous behaviour of a device has been openly disclosed, the device should be promptly patched, or the triggering event should be blocked.

To avoid these types of security issues, we propose an approach for monitoring the behavior of smart home devices and timely detect potential vulnerabilities. The proposed approach is based on defensive programming combined with the adoption of open source intelligence tools ¹ on the interconnected devices through the use of Shodan APIs ².

2. Smart Consumption in Smart Homes

In the literature there are many definitions for the concept of a *Smart home* [8]. Generally, a smart home is a system including several appliances and services connected in a network in such a way that they can be monitored and managed. In Figure 1 a smart home case study is represented through a high level architecture. A set of connected things form the local network, and in particular a smart meter monitors the energy production and consumption of the building and, according to some thresholds of energy produced or consumed, various smart objects in the smart home system could be activated or deactivated. Usually commercial smart meter monitors offer also APIs, in order to provide customization capabilities, and build third party applications interacting with the meter's data. In this example, the smart meter offers an API for sensing electrical production with solar panels and power consumption in real time of the whole house. In this context, we can have a software system developed with customized source code (*Third-Party App*) that continuously *reads* the smart meter API available from a local IP address and controls all the smart objects connected to the LAN. The main application can be seen as an intelligent energy consumption scenario, that is, if the solar panels are producing more than a certain amount of energy and the current energy consumption is very low, the software can decide to activate an energy intensive smart device, such as a washing machine.

If we consider an exemplary application that senses energy supply/demand and activates devices accordingly, the response returned by the smart meter API can be sim-

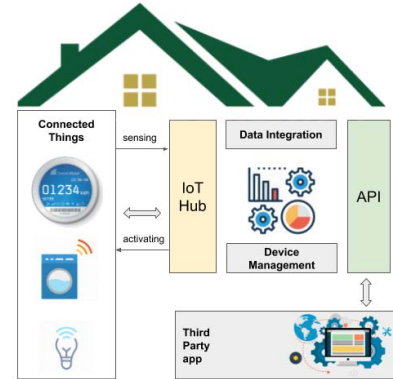


Figure 1. Architecture of the presented case study.

plified as in Listing 1³. Usually smart appliances provide data in common interchange formats, e.g., JSON, XML, so other applications can easily interact. REST API are provided in these cases, whereby this paradigm offers an application program interface (API) that uses HTTP requests to GET, PUT, POST and DELETE data. The first attribute of the API's JSON response of the smart meter is the result of the GET call, in which two important values are reported: the house's consumption of energy in kW (in this case 2.0) and the instant electricity production of the solar panels (in this moment 0). This would characterize a moment in which the solar panels are not producing, e.g., at night or cloudy day and the consumption is up to 2.0 KW, for instance activating a machine machine can range from 500 watt up to 1300 watt (1.3Kw). Additionally, the timestamp and the electricity price could be retrieved, but these are unnecessary for this case study. In this setting, we consider a simple Java application reading the smart meter API in order to make decisions about the activation of smart devices.

Listing 1. Sample GET response from the the smart meter's API.

```
{
  "electricity": {
    "consuming": {
      "actual": {
        "reading": 2.0,
        "unit": "kW"
      }
    },
    "received": {
      "actual": {
        "reading": 0,
        "unit": "kW"
      }
    }
  },
  "gas": {
    "reading": 0.5,
    "unit": "m3"
  }
}
```

The reported application is a simplified version of a complex application that also considers the daily history of electricity production/consumption and matches the information with a weather station, in order to guarantee

1. <https://osintframework.com>

2. <https://www.shodan.io>

3. This is a simplification of how an API for smart meter can be implemented, inspired by a commercial product: OWL Intuition PV.

that the production of solar energy will be sufficient for the needed amount of time. For sake of simplicity we assume that the *sensing* and *activating* methods are part of a scheduled routine that also detects other useful information, but Listing 2 only contains a snippet of code doing the simple task we are discussing.

Consider this snippet as an example of third-party code that works with the IoT devices. It continuously calls the smart meter API URL and stores the resulting JSON in the `smartmeter` variable. Then this application checks if the energy available is more than 5 kW and, if so, it instantiates a device as a new `Thing` which is activated according to the priority list; otherwise, it continues to monitor the API until this condition is matched.

Listing 2. Example of Third Party app

```
while (true) {
    URL api =
        new URL("https://192.168.1.12/"+
            "smarhome/meter/get");
    Thing smartmeter = new Thing();
    smartmeter.setIpAddress("192.168.1.12");
    String content =
        MyFileUtils.urlToString(api, "utf-8");
    JSONObject toJsonObject =
        new JSONObject(content);
    JSONObject smartmeter =
        toJsonObject.get("electricity");
    Double consumption =
        smartmeter.get("consuming")
            .get("actual")
            .get("reading");
    Double received = ...;
    Double delta = 5.0;
    if (received - consumption >= delta) {
        Thing t = new Thing();
        t.activate();
        ...
    }
}
```

If the smart meter has exposed vulnerabilities, it can be the target of malicious attacks which could affect the reading shown in the API response. Optimistically, this could result in the undesired activation or deactivation of devices, affecting the electricity consumption of the smart home. However, such an attack could be escalated to an even worse situation, causing incidents such as power outages or even a voltage overload.

3. Detecting Vulnerabilities in 3rd Party Apps

In IoT-enabled SoS, smart objects are usually connected to sensors, which collect information about the environment, and actuators, which perform actions according to the collected information. If one such smart object is subject to a vulnerability, it could be exploited as an entry point and expose the entire SoS to malicious interference. One way of protecting smart objects from attackers is by using tools to automatically and timely detect vulnerable devices. One such tool is Shodan, which provides a dashboard and APIs listing devices currently publicly exposed over IP to anyone on the Internet. An example of a Shodan entry can be a vulnerability publicly available showing how to execute a command injection to a Smart Camera connected over IP. This would mean that if the user recognise this device as part of its network, he

/ she should take immediately countermeasures to deal with this issue. Shodan can be used to inspect if one of the systems in the network, subject of our study, has a potential vulnerability, by checking if it is exposing a public interface to the Internet. It is important to observe that, in a SoS context, the API's purpose is to detect devices that have services publicly exposed to the Internet, along with details about these services. Once it is known that a device is reachable by Shodan, further analysis must be performed to determine whether or not a vulnerability exists, so it can finally be patched if needed.

A constant monitoring using Shodan's APIs will help an SoS to adapt and recalculate in case a vulnerability is exposed by one of its constituent systems. The Shodan API provides several features that could be valuable to detect potential vulnerabilities in a smart environment, such as: IP lookup, host search, IP crawl, automatic alert in a given list of IP addresses.

4. Defensive Programming against SoS Vulnerabilities

The approach we propose to deal with the case study presented in section 2 and its potential vulnerabilities is to use a well-known programming paradigm called *Defensive programming* [9]. According to such paradigm, developers must assume that any possible vulnerability will be exploited and thus apply good practices to develop code that is secure against attacks. One such practice consists in preserving code correct execution by using *assertions*. The idea is to add assertions in the code so to check if the code is executing correctly and produced values are within expectations. As known, an assertion is in fact an expression that must be evaluated *true* if the program is running correctly; if not, defensive programming requires that the execution be terminated. Defensive programming also considers how the program can be stopped securely. By combining this paradigm with the functionalities of a vulnerability monitoring systems like Shodan, we can handle SoS vulnerabilities in multiple scenarios. In the case study represented in Figure 1, considering assertions in the development of third party applications may help to check if the interactions among devices involves a *Thing* that appears in the Shodan directory, as vulnerable. If we find that even one of the smart objects is exposed to vulnerabilities the program will notify the system manager and / or alter its behaviour. Of course this is applicable to the smart thing software itself, even if it results easier to be managed with respect to third party apps, making this interleaving connections more complex. As such, defensive programming can be a good practice in the development of third-party applications for SoS but it is not a silver bullet, nor the unique solution. For instance, the code reported in listing 2, in particular every occurrence of the concept `Thing`, should be surrounded by an assertion checking if this device appears as exposed on the Shodan repository. To provide a sample of this approach, we simulated the Shodan API response locally and the result is reported in Listing 3. We had to simulate the response because the Shodan database is (fortunately) not densely populated, and we would not like to expose a real vulnerability of a third-party device for our experiment. This result is the

JSON response of the REST call `/shodan/host/ip`, checking if the IP indicated as parameter appears in the list of exposed devices.

Listing 3. Sample GET response from Shodan's API.

```
{
  "region_code": null,
  "ip": "192.168.1.12",
  "country_name": "Italy", "hostnames": [],
  "data": [
    {
      "product": "Smart Meter Device of the GSSI",
      "os": null,
      "timestamp": "2014-01-12T18:25:41",
      "isp": "Telecom"
    }
  ]
}
```

This result highlights that the smart meter used in the application, connected then with the required ip, is exposed and might be affected by a vulnerability, so it is important to alert the manager of the smart home.

The code reported in Listing 3 could be easily extended with the defensive strategy we propose and, in particular, the API call for getting the electrical information from the smart meter should be refined as reported in Listing 4.

Listing 4. Defensive Programming Example

```
try {
  Shodan shodan = new Shodan(key);
  if (received - consumption >= delta) {
    assert
      shodan.checkIfDeviceIsVulnerable(
        smartmeter.getIp_address()
      ):
        "Device seems to be vulnerable";
    Thing t = new Thing();
    t.activate();
  }
} catch (AssertionError error) {
  // Output expected AssertionErrors.
  System.err.println(
    "The application will be stopped");
  // here the developer can customize the
  // actions to be undertaken
  return;
}
```

This very simple code, refined in the perspective of defensive programming, prevents the activation of the device controlled by parameters of the smart meter in case the smart meter appears in the Shodan repository.

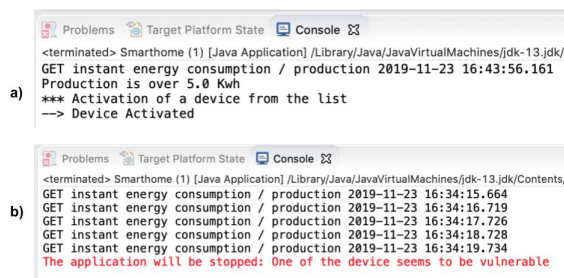


Figure 2. Log of the running application

The code reported in Listing 4 should replace the affected part of the code in Listing 2. The main point deserving attention is the assertion in which the `shodan` library

with the `checkIfDeviceIsVulnerable` method to check if the device is listed in the Shodan repository. If the assertion fails, the exception will be treated and the program will be stopped. This behaviour can be further customized to better manage the flow of activation or notification to the developer.

The log reported in Figure 2 reports two flows of execution of the code. Figure 2 a) reports the monitoring in which a new device is activated when there is sufficient electricity available. In Figure 2 b) the condition is not matched, so when the event is triggered the assertion fails, warning the system administration of a potential vulnerability and halting the application. This log simply shows the different flows in the cases where the assertion passes or fails. In the a) part, the log shows that the device, not being listed in the Shodan repository, triggers the activation of another device from the priority list. In the option b) the device is actually listed during the monitoring phase and then an alert (highlighted in red) is raised to warn the system administrator to resolve the issue. Of course this example has been tested in a local environment with an Eclipse installation to simulate the home environment, the API and the flow. The action undertaken when the application is discovered as vulnerable is limited to a console print out. We plan to simulate this in a real scenario with sensing devices and a real case study. It worth noting that while this paper uses Shodan as the repository of the vulnerabilities, the approach we propose is general enough to be extended to other sources. More in general, Open Source Intelligence (OSINT) refers to the collection of information from public sources to gather data of publicly available information sources about individuals and business intelligence purposes. Based on it this approach can be extended to add other sources in order to gather more information about exploits or other info about our devices vulnerabilities.

5. Relevant Application Scenarios

Beyond the simple case discussed in the previous section, we foresee several other possible scenarios in which defensive programming combined with OSINT application can support SoS cybersecurity. In this section we briefly discuss some of such possible scenarios.

Assertions Actions The used assertion simply stops the program to avoid possible unwanted behaviour without planning a possible action of resolution. For this reason, a notification mechanism could be introduced to avoid stopping the program's execution and react accordingly and manually on the affected code. This point can be further automated with self adaptation plans.

Self-adaptation Self-adaptive software checks its own behaviour and evolves autonomously when the evaluation indicates that it is not possible to accomplish what the software is intended to do [10]. Self adapting may be a positive strategy if the Shodan library reveals that one of the device results as affected by vulnerabilities. Instead of stopping execution, the program can self-adapt its behaviour with a reconfiguration plan. For instance, if the assertion fails the program could try to continue to coordinate the activation of other devices without relying on the affected device. An adaptation plan could be a lookup for other smart meters connected to the network or

use historical data to make informed decisions (AI could be the cutting edge technology).

Online Testing Our approach can be leveraged for promoting the application of proactive online testing activities, for the purposes of security assessment [11]. Online testing consists of continuing the execution of test cases on the system in production, and is recently gaining attention, motivated by the continuous evolution and complexity of modern pervasive systems. This is especially true in dynamic contexts such as smart homes, and more in general for any SoS. We envisage a potential application of an online testing strategy that by periodically checking the inserted assertions (i.e., considering a test suite aiming at covering the included assertions), would allow to timely detect, and react against, possible vulnerabilities, before these are experienced by the SoS end-users. Alternatively, we could instead inject security attacks on purpose, similarly to Netflix Chaos Monkey concept [12], so to test if the system is ready to react to attacks.

Security Testability It is well known since the early 90's that proper placement of assertions improves a program's testability [13]. By including *ad hoc* assertions for dealing with potential vulnerabilities, we are improving the potential of disclosing possible attacks and hence naturally increase a system testability for security. Of course, such statement is strictly dependent on the quality of the assertion themselves, therefore it is important in future work to study the effectiveness and extent of the assertions we produce, and where we embed them.

6. Related Works

In the literature, the issue of security in smart city systems is already a hot topic and different approaches to solve it have been proposed. With regard to the smart city domain, in [14] the authors discuss various privacy and security solutions, recommendations, and standards for smart cities and their services. The challenges highlighted here are given by the exploitation of ICT to offer high quality smart city services to the people. Consequently, IoT contexts present several security, privacy and ethical challenges as exposed in [15]. The issues presented here are due to the complexity of IoT systems and the heterogeneity of their components. The authors highlight also the security issues related to the connections between IoT objects. Thus, they propose a threat model for all the smart city areas, including smart home. Moreover, in [16] the authors present the results of a security assessment of IoT devices extending a public dataset of Shodan queries. From this study, they extracted query terms used to access to a class of IoT devices, showing how easy is to detect vulnerabilities in IoT devices. These queries can serve as a starting point for further application of Shodan in cybeseurity applications. Focusing on the smart home context, in [17] is described the context of smart buildings in which there is the need of managing the overflowing of energy generation and it is raised up the need of the integration of cybersecurity testing. In particular, here they highlight the importance of knowing what type of attack is happening to be able to implement a digital forensic readiness. In [18] are exposed the risks of having cloud-based IoT technologies in the different smart city contexts. In particular, for the smart buildings context they propose

a robust Intrusion Detection System (IDS) based on machine learning algorithms that detects any abnormality in the traffic of data in the cloud. [19] proposes an approach that calculate threat factors based on different features (e.g., system architecture, networks, operating systems, database schemas, encryption techniques, security policies, business operations, and corporate data). The calculated factors are responsible for telling how a smart city system can face cyber-threats in terms of robustness. The work in [20] proposes an architecture for Smart Homes that facilitates security analysis of the IoT systems in the house, giving a global view of the devices and networks composing the smart home. This approach wants to sketch the different systems of a smart home system in order to know what can be the crucial vulnerabilities. In [21], the authors highlight the challenges of preserving the security of SoS domains due to their characteristics (e.g., operational independence of constituent systems, absence of central authority). Here, one of the main security challenge is to manage cascading attacks, thus, the authors propose a DSML to represent SoS security architecture enabling the discovery, analysis and resolution of cascading attacks. With regard to the defensive programming paradigm, in the literature we can find how its exploitation can be used to deal with cyber-security issues. In [22] a defensive programming approach is exposed to a sensor architecture in order to identify sensor malfunctions upon their occurrence. This continuous checking approach is implemented as a model containing a set of rules that promptly alerts about a malfunction and contributes in diagnosing the problem. Regarding the IoT context, in [23] the authors expose security and privacy issues in the deployment of smart camera sensors. Here, it is explained how can be exploited the defensive programming paradigm to ensure trustworthiness in a smart camera sensors network. In [24] an iterative process for security management in systems characterised by an high inter-connectivity (e.g. Smart Grids) is proposed. Here, four security layers are implemented aiming to increase the security of decentralized control algorithms for critical infrastructures. In the first of these layers, some recommended best practices can be found, including defensive programming, to help in preserving from defeats the infrastructure single nodes in order to prevent infections of the other nodes in the infrastructure. Another approach for cybersecurity in a smart city environment is trust management [25], in which devices store information about each other and maintain a level of trust based on past interactions. This approach can help identify faulty or misbehaving members of the network, although it doesn't stop an external attacker from taking control of a previously trusted, but vulnerable, device.

7. Conclusions

Cybersecurity is a real issue in the development of smart services in the smart home domain. Different smart objects communicate automatically and autonomously increasing their exposure to vulnerabilities that can affect the entire SoS. This ripple effect can endanger everyday life activities including operations that can even include safety issues. In this paper we introduced an approach for the continuous monitoring of SoS that combines defensive

programming techniques with the usage of Shodan APIs. We illustrated a possible application of the approach in a smart home environment that can of course be extended to more complex scenarios and domains, e.g., smart cities. For this case study, the presented approach would avoid failures that could lead to energy wastage, appliances breakdowns or disclosure of personal data. In the smart city domain there are other contexts in which this approach could be applied. More in general, whenever we have a SoS implying the collaboration among different smart objects connected to a network, the approach can help timely detect potentially exposed vulnerabilities. For instance, in a smart mobility environment in which the traffic is monitored and managed using IoT sensors connected in a network, we can use the same approach of checking their IP addresses. Moreover, in this context vulnerabilities exposure could produce environmental issues in terms of air pollution. Nowadays several researchers advocate a paradigm of security-by-design [26], according to which a system must be built to be secure since its very inception. In the case of SoS, such a paradigm appears hardly applicable, because of the inherent dynamism and autonomic nature of such systems. We see our proposal of adopting defensive programming and of leveraging OSINT technology as a preliminary attempt to get closer to secure-by-design SoS. This work is directed to SoS developers and researchers, and we hope can provide guidelines or inspiration to be taken under consideration. In future work, we aim at developing a complete framework for more applications and further case studies. Moreover we plan to investigate model based design and development for secure systems. Using Model Driven Engineering (MDE) helps to shift the focus from code-centric techniques to code generation. In this context it would be interesting to investigate whether designing systems with models may support the automation of some steps. For instance we could investigate the automatic generation of assertions in our applications with specific protected code areas that can be further customized by developers.

References

- [1] M. W. Maier, "Architecting principles for systems-of-systems," *Systems Engineering*, vol. 1, no. 4, pp. 267–284, 1998.
- [2] C. B. Nielsen, P. G. Larsen, J. Fitzgerald, J. Woodcock, and J. Pelska, "Systems of systems engineering: basic concepts, model-based techniques, and research directions," *ACM Computing Surveys*, vol. 48, no. 2, pp. 1–41, 2015.
- [3] A. Al-Fuqaha, M. Guizani, M. Mohammadi, M. Aledhari, and M. Ayyash, "Internet of things: A survey on enabling technologies, protocols, and applications," *IEEE Communications Surveys Tutorials*, vol. 17, no. 4, pp. 2347–2376, 2015.
- [4] R. J. Robles, T.-h. Kim, D. Cook, and S. Das, "A review on security in smart home development," *International Journal of Advanced Science and Technology*, vol. 15, 2010.
- [5] N. Neshenko, E. Bou-Harb, J. Crichigno, G. Kaddoum, and N. Ghani, "Demystifying iot security: An exhaustive survey on iot vulnerabilities and a first empirical look on internet-scale iot exploitations," *IEEE Communications Surveys Tutorials*, vol. 21, no. 3, pp. 2702–2733, 2019.
- [6] N. Komninos, E. Philippou, and A. Pitsillides, "Survey in smart grid and smart home security: Issues, challenges and countermeasures," *IEEE Communications Surveys Tutorials*, vol. 16, no. 4, pp. 1933–1954, 2014.
- [7] M. Abomhara *et al.*, "Cyber security and the internet of things: vulnerabilities, threats, intruders and attacks," *Journal of Cyber Security and Mobility*, vol. 4, no. 1, pp. 65–88, 2015.
- [8] Li Jiang, Da-You Liu, and Bo Yang, "Smart home research," in *Proceedings of 2004 International Conference on Machine Learning and Cybernetics (IEEE Cat. No.04EX826)*, vol. 2, 2004, pp. 659–663.
- [9] J. K. Teto, R. Bearden, and D. C.-T. Lo, "The impact of defensive programming on i/o cybersecurity attacks," in *Proceedings of the SouthEast Conference*, 2017, pp. 102–111.
- [10] R. Laddaga, "Creating robust software through self-adaptation," *IEEE Intelligent Systems*, vol. 14, no. 3, pp. 26–29, 1999.
- [11] A. Bertolino, G. De Angelis, S. Kellomaki, and A. Polini, "Enhancing service federation trustworthiness through online testing," *Computer*, vol. 45, no. 1, pp. 66–72, 2011.
- [12] C. Bennett and A. Tseitlin, "Chaos monkey released into the wild," *Netflix Tech Blog*, vol. 30, 2012.
- [13] J. M. Voas and K. W. Miller, "Software testability: The new verification," *IEEE software*, vol. 12, no. 3, pp. 17–28, 1995.
- [14] R. Khatoun and S. Zeadally, "Cybersecurity and privacy solutions in smart cities," *IEEE Communications Magazine*, vol. 55, no. 3, pp. 51–59, 2017.
- [15] A. Seeam, O. S. Ogbeh, S. Guness, and X. Bellekens, "Threat modeling and security issues for the internet of things," in *2019 Conference on Next Generation Computing Applications (NextComp)*, 2019, pp. 1–8.
- [16] A. Albatineh and I. Alsmadi, "Iot and the risk of internet exposure: Risk assessment using shodan queries," in *2019 IEEE 20th WoWMoM International Symposium*, 2019, pp. 1–5.
- [17] E. Bajramovic, K. Waedt, A. Ciriello, and D. Gupta, "Forensic readiness of smart buildings: Preconditions for subsequent cybersecurity tests," in *2016 IEEE International Smart Cities Conference (ISC2)*, Sep. 2016, pp. 1–6.
- [18] N. Sengupta, "Designing cyber security system for smart cities," in *Smart Cities Symposium 2018*, April 2018, pp. 1–6.
- [19] P. Wang, A. Ali, and W. Kelly, "Data security and threat modeling for smart city infrastructure," in *2015 International Conference on Cyber Security of Smart Cities, Industrial Control System and Communications (SSIC)*, Aug 2015, pp. 1–6.
- [20] K. Ghirardello, C. Maple, D. Ng, and P. Kearney, "Cyber security of smart homes: Development of a reference architecture for attack surface analysis," in *Living in the Internet of Things: Cybersecurity of the IoT - 2018*, March 2018, pp. 1–10.
- [21] J. El Hachem, Z. Y. Pang, V. Chiprianov, A. Babar, and P. Anriorte, "Model driven software security architecture of systems-of-systems," in *2016 23rd Asia-Pacific Software Engineering Conference (APSEC)*, 2016, pp. 89–96.
- [22] A. Carteron, C. Consel, and N. Volanschi, "Improving the Reliability of Pervasive Computing Applications By Continuous Checking of Sensor Readings," in *IEEE International Conference on Ubiquitous Intelligence and Computing*, Toulouse, France, Jul. 2016.
- [23] M. Loughlin and A. Adnane, "Privacy and trust in smart camera sensor networks," in *2015 10th International Conference on Availability, Reliability and Security*, Aug 2015, pp. 244–248.
- [24] M. Stübs, "Towards emergent security in low-latency smart grids with distributed control," in *2018 IEEE International Conference on Communications, Control, and Computing Technologies for Smart Grids (SmartGridComm)*, Oct 2018, pp. 1–6.
- [25] M. L. Loper and B. Swenson, "Machine to machine trust in smart cities," in *2017 IEEE 37th International Conference on Distributed Computing Systems (ICDCS)*, 2017, pp. 1887–1889.
- [26] J. Geismann, C. Gerking, and E. Bodden, "Towards ensuring security by design in cyber-physical systems engineering processes," in *Proceedings of the 2018 International Conference on Software and System Process*, 2018, pp. 123–127.

2020 IEEE European Symposium on Security and Privacy Workshops (EuroS&PW) EuroSPW 2020

Table of Contents

Message from the General Chairs	xv
Message from the Euro S&P 2020 Program Chairs	xvi
Organizing Committee	xviii
The Workshops of the 5th IEEE European Symposium on Security and Privacy - Preface ..	xix
<i>Alessio Merlo (DIBRIS, University of Genoa, Italy) and Luca Viganò (King's College London, London, UK)</i>	

CACOE: Cyberange Technologies Workshop

International Workshop on Cyber Range Technologies and Applications (CACOE 2020)	1
<i>Maria Leitner (AIT Austrian Institute of Technology) and Teodor Sommestad (Swedish Defence Research Agency FOI)</i>	
Automated Penetration Testing Using Deep Reinforcement Learning	2
<i>Zhenguo Hu (Japan Advanced Institute of Science and Technology), Razvan Beuran (Japan Advanced Institute of Science and Technology), and Yasuo Tan (Japan Advanced Institute of Science and Technology)</i>	
Comprehensive Cyber Arena; the Next Generation Cyber Range	11
<i>Mika Karjalainen (Institute of Information Technology, JAMK University of Applied Sciences, Jyväskylä, Finland) and Tero Kokkonen (Institute of Information Technology, JAMK University of Applied Sciences, Jyväskylä, Finland)</i>	
Evaluation of Information Elements in a Cyber Incident Report	17
<i>Patrik Lif (Swedish Defence Research Agency), Stefan Varga (KTH Royal Institute of Technology, Swedish Armed Forces Headquarters, Stockholm, Sweden), Mikael Wedlin (Swedish Defence Research Agency), David Lindahl (Swedish Defence Research Agency), and Mats Persson (Swedish Defence Research Agency)</i>	
Learning Analytics Perspective: Evidencing Learning from Digital Datasets in Cybersecurity Exercises	27
<i>Kaie Maennel (Tallinn University of Technology)</i>	
CRATE Exercise Control - A Cyber Defense Exercise Management and Support Tool	37
<i>Jonas Almroth (Swedish Defence Research Agency (FOI)) and Tommy Gustafsson (Swedish Defence Research Agency (FOI))</i>	

Replicated Testbed Experiments for the Evaluation of a Wide-range of DDoS Defenses	46
<i>Alefiya Hussain (USC/Information Sciences Institute), David DeAngelis (USC/Information Sciences Institute), Erik Kline (USC/Information Sciences Institute), and Stephen Schwab (USC/Information Sciences Institute)</i>	
An Experimental Approach for Estimating Cyber Risk: A Proposal Building upon Cyber Ranges and Capture the Flags	56
<i>Giorgio Di Tizio (University of Trento), Fabio Massacci (University of Trento), Luca Allodi (Technical University of Eindhoven), Stanislav Dashevskyi (Forescout Technologies), and Jelena Mirkovic (University of Southern California)</i>	

CyberCert: Cybersecurity Certification

First International Workshop on Lightweight and Incremental Cybersecurity Certification	66
<i>Philippe Massonet (CETIC Research Center)</i>	
How to Stop Crashing more than Twice: A Clean-Slate Governance Approach to IT Security	67
<i>Tobias Fiebig (TU Delft)</i>	
From Lightweight Cybersecurity Assessment to SME Certification Scheme in Belgium	75
<i>Christophe Ponsard (CETIC), Philippe Massonet (CETIC), Jeremy Grandclaudon (CETIC), and Nicolas Point (Multitel)</i>	
Towards Incremental Safety and Security Requirements Co-Certification	79
<i>Andrea Morgagni (Leonardo), Philippe Massonet (CETIC Research Center), Sébastien Dupont (CETIC Research Center), and Jeremy Grandclaudon (CETIC Research Center)</i>	
Cybersecurity Certification for Agile and Dynamic Software Systems – a Process-Based Approach	85
<i>Volkmar Lotz (SAP Labs France)</i>	
JCMathLib: Wrapper Cryptographic Library for Transparent and Certifiable JavaCard Applets	89
<i>Vasilios Mavroudis (University College London) and Petr Svenda (Masaryk University)</i>	

EuroUSEC: European Workshop on Usable Security

A Cross-Platform Evaluation of Privacy Notices and Tracking Practices	97
<i>Maryam Mehrnezhad (Newcastle University)</i>	
Data Sharing in Mobile Apps — User Privacy Expectations in Europe	107
<i>Quermann Nils (Ruhr-Universität Bochum) and Degeling Martin (Ruhr-Universität Bochum)</i>	
GDPR Reality Check – Claiming and Investigating Personally Identifiable Data from Companies	120
<i>Fatemeh Alizadeh (University of Siegen), Timo Jakobi (University of Siegen), Alexander Boden (Fraunhofer Institute for Applied Information Technology), Gunnar Stevens (University of Siegen), and Jens Boldt (University of Siegen)</i>	

Analysis of Publicly Available Anti-phishing Webpages: Contradicting Information, Lack of Concrete Advice and Very Narrow Attack Vector	130
<i>Mattia Mossano (Karlsruhe Institute of Technology), Kami Vaniea (University of Edinburgh), Lukas Aldag (Karlsruhe Institute of Technology), Reyhan Düzgün (Karlsruhe Institute of Technology), Peter Mayer (Karlsruhe Institute of Technology), and Melanie Volkamer (Karlsruhe Institute of Technology)</i>	
Investigating Teenagers' Ability to Detect Phishing Messages	140
<i>James Nicholson (Northumbria University), Yousra Javed (National University of Sciences and Technology), Matt Dixon (Northumbria University), Lynne Coventry (Northumbria University), Opeyemi Dele Ajayi (Northumbria University), and Philip Anderson (Northumbria University)</i>	
Do Women in Conservative Societies (Not) Follow Smartphone Security Advice? a Case Study of Saudi Arabia and Pakistan	150
<i>Elham Al Qahtani (University of North Carolina Charlotte), Yousra Javed (National University of Sciences and Technology), Heather Lipford (University of North Carolina Charlotte), and Mohamed Shehab (University of North Carolina Charlotte)</i>	
Vision: I Don't Want to use My Phone! A Cognitive Walkthrough for YubiKeys	160
<i>Claudia Bischoff (University of Bonn), Eva Gerlitz (Fraunhofer FKIE), and Matthew Smith (University of Bonn, Fraunhofer FKIE)</i>	
Vision: Investigating Web API Developer Experience in Relation to Terms of Service and Privacy Policies	166
<i>Aidah Ichario (Heriot-Watt University) and Manuel Maarek (Heriot-Watt University)</i>	
Vision: Shred If Insecure – Persuasive Message Design as a Lesson and Alternative to Previous Approaches to Usable Secure Email Interfaces	172
<i>Jan Tolsdorf (Hochschule Bonn-Rhein-Sieg University of Applied Sciences) and Luigi Lo Iacono (Hochschule Bonn-Rhein-Sieg University of Applied Sciences)</i>	
Vision: What If They All Die? Crypto Requirements for Key People	178
<i>Chan Nam Ngo (University of Trento, Trento, Italy), Daniele Friolo (Sapienza University of Rome, Rome, Italy), Fabio Massacci (University of Trento, Trento, Italy), Daniele Venturi (Sapienza University of Rome, Rome, Italy), and Ettore Battaiola (Cassa Centrale Banca, Trento, Italy)</i>	
Vision: Why Johnny Can't Configure Smart Home? A Behavioural Framework for Smart Home Privacy Configuration	184
<i>Joseph Shams (King's College London), Nalin A. G. Arachchilage (La Trobe University, Australia), and Jose M. Such (King's College London)</i>	
Simulating the Effects of Social Presence on Trust, Privacy Concerns & Usage Intentions in Automated Bots for Finance	190
<i>Magdalene Ng (Newcastle University), Kovila P.L. Coopamootoo (Newcastle University), Ehsan Toreini (Newcastle University), Mhairi Aitken (Newcastle University), Karen Elliot (Newcastle University), and Aad van Moorsel (Newcastle University)</i>	

Cash, Cards or Cryptocurrencies? A Study of Payment Culture in Four Countries	200
<i>Karoline Busse (University of Bonn), Mohammad Tahaei (University of Edinburgh), Katharina Krombholz (CISPA Helmholtz Center for Information Security), Emanuel von Zezschwitz (University of Bonn), Matthew Smith (University of Bonn/Fraunhofer FKIE), Jing Tian (Zhejiang University), and Wenyuan Xu (Zhejiang University)</i>	
Improving Non-Experts' Understanding of End-to-End Encryption: An Exploratory Study	210
<i>Wei Bai (University of Maryland, College Park), Michael Pearson (University of Maryland, College Park), Patrick Gage Kelley (Google LLC), and Michelle L. Mazurek (University of Maryland, College Park)</i>	
Making Encryption Feel Secure: Investigating how Descriptions of Encryption Impact Perceived Security	220
<i>Verena Distler (University of Luxembourg), Carine Lallemand (University of Luxembourg / Eindhoven University of Technology), and Vincent Koenig (University of Luxembourg)</i>	
End User and Expert Perceptions of Threats and Potential Countermeasures	230
<i>Simon Anell (Helmholtz Center for Information Security (CISPA), Saarland Informatics Campus), Lea Gröber (Helmholtz Center for Information Security (CISPA)), and Katharina Krombholz (Helmholtz Center for Information Security (CISPA))</i>	
Security Should be there by Default: Investigating how Journalists Perceive and Respond to Risks from the Internet of Things	240
<i>Anjuli R. K. Shere (University of Oxford, UK), Jason R. C. Nurse (University of Kent, UK), and Ivan Flechais (University of Oxford, UK)</i>	
Tech Pains: Characterizations of Lived Cybersecurity Experiences	250
<i>Huixin Tian (Indiana University Bloomington), Chris Kanich (University of Illinois at Chicago), Jason Polakis (University of Illinois at Chicago), and Sameer Patil (Indiana University Bloomington)</i>	

HotSpot: Hot Topics in the Principles of Security and Trust

HotSpot Preface	260
<i>Joshua Guttman (Worcester Polytechnic Institute and MITRE Corporation) and Sebastian Mödersheim (DTU Compute)</i>	
QQIF: Quantum Quantitative Information Flow (Invited Paper)	261
<i>Arthur Americo (EECS, Queen Mary University of London) and Pasquale Malacaria (EECS Queen Mary University of London)</i>	
Security across Abstraction Layers: Old and New Examples	271
<i>Frank Piessens (KU Leuven)</i>	
A Game of Drones: Extending the Dolev-Yao Attacker Model with Movement	280
<i>Andrew Cook (King's College London, London, UK) and Luca Viganò (King's College London, London, UK)</i>	
Explainable Security	293
<i>Luca Viganò (King's College London, London, UK) and Daniele Magazzeni (King's College London, London, UK)</i>	

IWPE: 6th International Workshop on Privacy Engineering

Preface on the International Workshop on Privacy Engineering 2020 (IWPE'20)	301
<i>Jose M. Del Alamo (Universidad Politécnica de Madrid), Jose Such (King's College London), Isabel Wagner (De Montfort University), and Marvin Ramokapane (University of Bristol)</i>	
LINDDUN GO: A Lightweight Approach to Privacy Threat Modeling	302
<i>Kim Wuyts (imec-DistriNet, KU Leuven), Laurens Sion (imec-DistriNet, KU Leuven), and Wouter Joosen (imec-DistriNet, KU Leuven)</i>	
Shedding Light on Web Privacy Impact Assessment: A Case Study of the Ambient Light Sensor API	310
<i>Olejník Lukasz (European Data Protection Supervisor)</i>	
The Never-Ending Story: On the Need for Continuous Privacy Impact Assessment	314
<i>Laurens Sion (imec-DistriNet, KU Leuven), Dimitri Van Landuyt (imec-DistriNet, KU Leuven), and Wouter Joosen (imec-DistriNet, KU Leuven)</i>	
Extracting Layered Privacy Language Purposes from Web Services	318
<i>Kalle Hjerpppe (University of Turku), Jukka Ruohonen (University of Turku), and Ville Leppänen (University of Turku)</i>	
On Compliance of Cookie Purposes with the Purpose Specification Principle	326
<i>Imane Fouad (INRIA), Cristiana Santos (Inria), Feras Al Kassar (SAP Labs), Nataliia Bielova (Inria), and Stefano Calzavara (Universita Ca' Foscari, Italy)</i>	
A Siamese Adversarial Anonymizer for Data Minimization in Biometric Applications	334
<i>Giuseppe Garofalo (imec-DistriNet, KU Leuven), Tim Van hamme (imec-DistriNet, KU Leuven), Davy Preuveneers (imec-DistriNet, KU Leuven), and Wouter Joosen (imec-DistriNet, KU Leuven)</i>	
Enhancing Privacy via Hierarchical Federated Learning	344
<i>Aidmar Wainakh (Technical University of Darmstadt), Alejandro Sanchez Guinea (Technical University of Darmstadt), Tim Grube (Technical University of Darmstadt), and Max Mühlhäuser (Technical University of Darmstadt)</i>	
Reconciling Privacy and Utility for Energy Services – An Application to Demand Response Protocols	348
<i>Franklin Leukam Lako (EDF Lab Paris-Saclay - SAMOVAR, Télécom SudParis), Paul Lajoie-Mazenc (EDF Lab Paris-Saclay), and Maryline Laurent (SAMOVAR, Télécom SudParis)</i>	

S&B: Security & Privacy on the Blockchain

IEEE S&B 2020: 4th IEEE Workshop on Security and Privacy on the Blockchain	356
<i>Tim Ruffing (Blockstream) and Florian Tschorsch (Technische Universität Berlin)</i>	
FileBounty: Fair Data Exchange	357
<i>Simon Janin (X80 Security), Kaihua Qin (Imperial College London), Akaki Mamagishvili (ETH Zurich), and Arthur Gervais (Imperial College London)</i>	

Performance Trade-offs in Design of MimbleWimble Proofs of Reserves	367
<i>Suyash Bagad (Indian Institute of Technology Bombay) and Saravanan Vijayakumaran (Indian Institute of Technology Bombay)</i>	
zkRelay: Facilitating Sidechains Using zkSNARK-based Chain-Relays	378
<i>Martin Westerkamp (Technische Universität Berlin) and Jacob Eberhardt (Technische Universität Berlin)</i>	
A Quantitative Analysis of Security, Anonymity and Scalability for the Lightning Network	387
<i>Sergei Tikhomirov (University of Luxembourg), Pedro Moreno-Sanchez (TU Wien), and Matteo Maffei (TU Wien)</i>	
Ostraka: Secure Blockchain Scaling by Node Sharding	397
<i>Alex Manuskin (Technion & IC3), Michael Mirkin (Technion & IC3), and Ittay Eyal (Technion & IC3)</i>	
An Automatic Detection and Analysis of the Bitcoin Generator Scam	407
<i>Emad Badawi (University of Ottawa), Guy-Vincent Jourdan (University of Ottawa), Gregor von Bochmann (University of Ottawa), and Iosif-Viorel Onut (IBM Centre for Advanced Studies)</i>	
CryptoWills: How to Bequeath Cryptoassets	417
<i>István András Seres (Eötvös Loránd University), Omer Shlomovits (KZen Research), and Pratyush Ranjan Tiwari (Ashoka University)</i>	

WACCO: 2nd Workshop on Attackers and Cyber-Crime Operations

WACCO 2020: The 2nd Workshop on Attackers and Cybercrime Operations: Co-held with IEEE European Symposium on Security and Privacy 2020	427
<i>Luca Allodi (Eindhoven University of Technology), Alice Hutchings (University of Cambridge), Fabio Massacci (University of Trento), Sergio Pastrana (University Carlos III of Madrid), and Marie Vasek (University College London)</i>	
A Tight Scrape: Methodological Approaches to Cybercrime Research Data Collection in Adversarial Environments	428
<i>Kieron Turk (University of Cambridge), Sergio Pastrana (Universidad Carlos III de Madrid), and Ben Collier (University of Cambridge)</i>	
#ISIS vs #ActionCountersTerrorism: A Computational Analysis of Extremist and Counter-extremist Twitter Narratives	438
<i>Fatima Zahrah (University of Oxford), Jason R. C. Nurse (University of Kent), and Michael Goldsmith (University of Oxford)</i>	
Mapping the Geography of Cybercrime: A Review of Indices of Digital Offending by Country ...	448
<i>Jonathan Lusthaus (University of Oxford), Miranda Bruce (UNSW Canberra Cyber), and Nigel Phair (UNSW Canberra Cyber)</i>	
Growth and Commoditization of Remote Access Trojans	454
<i>Veronica Valeros (Czech Technical University in Prague) and Sebastian Garcia (Czech Technical University in Prague)</i>	

My Boss is Really Cool: Malware-Induced Misperception in Workplace Communication through Covert Linguistic Manipulation of Emails	463
<i>Filipo Sharevski (DePaul University), Peter Jachim (DePaul University), Paige Treebridge (DePaul University), Audrey Li (DePaul University), and Adam Babin (DePaul University)</i>	
Don't Forget the Human: A Crowdsourced Approach to Automate Response and Containment against Spear Phishing Attacks	471
<i>Pavlo Burda (Eindhoven University of Technology), Luca Allodi (Eindhoven University of Technology), and Nicola Zannone (Eindhoven University of Technology)</i>	
Knowledge is Power: An Analysis of Discussions on Hacking Forums	477
<i>John McAlaney (Bournemouth University), Sarah Hambidge (Bournemouth University), Emily Kimpton (Bournemouth University), and Helen Thackray (University of Portsmouth)</i>	
A Social Network Analysis and Comparison of Six Dark Web Forums	484
<i>Ildiko Pete (University of Cambridge), Jack Hughes (University of Cambridge), Yi Ting Chua (University of Cambridge), and Maria Bada (University of Cambridge)</i>	
A Measurement Study on the Advertisements Displayed to Web Users Coming from the Regular Web and from Tor	494
<i>Adrian Bermudez-Villalva (University College London), Mirco Musolesi (University College London, University of Bologna), and Gianluca Stringhini (Boston University)</i>	
How Can Data from Fitness Trackers be Obtained and Analyzed with a Forensic Approach?	500
<i>Florian Hantke (Friedrich-Alexander-Universität Erlangen-Nürnberg) and Andreas Dewald (ERNW Research GmbH)</i>	
Typosquatting and Combosquatting Attacks on the Python Ecosystem	509
<i>Duc Ly Vu (University of Trento), Ivan Pashchenko (University of Trento), Fabio Massacci (University of Trento), Henrik Plate (SAP Security Research), and Antonino Sabetta (SAP Security Research)</i>	
Are You a Favorite Target for Cryptojacking? A Case-Control Study on the Cryptojacking Ecosystem	515
<i>Giorgio Di Tizio (University of Trento) and Chan Nam Ngo (University of Trento)</i>	

WTMC: Workshop on Traffic Measurements for Cybersecurity

Preface on the 5th International Workshop on Traffic Measurements for Cybersecurity	521
<i>Maciej Korczynski (Grenoble Alpes University), Wojciech Mazurczyk (Warsaw University of Technology), and Pedro Casas (Austrian Institute of Technology)</i>	
Discovering HTTPSified Phishing Websites Using the TLS Certificates Footprints	522
<i>Yuji Sakurai (Waseda University), Takuya Watanabe (NTT Secure Platform Laboratories), Tetsuya Okuda (NTT Secure Platform Laboratories), Mitsuaki Akiyama (NTT Secure Platform Laboratories), and Tatsuya Mori (Waseda University)</i>	

Feasibility of Large-Scale Vulnerability Notifications after GDPR	532
<i>Wissem Soussi (Univ. Grenoble Alpes, CNRS, France), Maciej Korczynski (Univ. Grenoble Alpes, CNRS, France), Sourena Maroofi (Univ. Grenoble Alpes, CNRS, France), and Andrzej Duda (Univ. Grenoble Alpes, CNRS, France)</i>	
The Forgotten Side of DNS: Orphan and Abandoned Records	538
<i>Raffaele Sommese (University of Twente), Mattijs Jonker (University of Twente), Roland van Rijswijk-Deij (University of Twente), Alberto Dainotti (CAIDA/UCSD), K.C. Claffy (CAIDA/UCSD), and Anna Sperotto (University of Twente)</i>	
TXting 101: Finding Security Issues in the Long Tail of DNS TXT Records	544
<i>Olivier van der Toorn (University of Twente), Roland van Rijswijk-Deij (University of Twente), Tobias Fiebig (TU Delft), Martina Lindorfer (TU Wien), and Anna Sperotto (University of Twente)</i>	
Into the DDoS Maelstrom: A Longitudinal Study of a Scrubbing Service	550
<i>Giovane C. M. Moura (SIDN Labs), Cristian Hesselman (SIDN Labs and University of Twente), Gerald Schaapman (NBIP), Nick Boerman (SIDN), and Octavia de Weerd (NBIP)</i>	
A Case of Identity: Detection of Suspicious IDN Homograph Domains Using Active DNS Measurements	559
<i>Ramin Yazdani (University of Twente), Olivier van der Toorn (University of Twente), and Anna Sperotto (University of Twente)</i>	
Forensic Analysis of Network Attacks: Restructuring Security Events as Graphs and Identifying Strongly Connected Sub-graphs	565
<i>Laetitia Leichtnam (CentraleSupélec, Univ. Rennes, IRISA, France), Eric Totel (IMT Atlantique, IRISA, Rennes, France), Nicolas Prigent (LSTI, St-Malo, France), and Ludovic Mé (INRIA, Univ. Rennes, IRISA, France)</i>	
WhatsThat? On the Usage of Hierarchical Clustering for Unsupervised Detection & Interpretation of Network Attacks	574
<i>Pavol Mulinka (Czech Technical University in Prague), Kensuke Fukuda (National Institute of Informatics), Pedro Casas (AIT Austrian Institute of Technology), and Lukas Kencl (Czech Technical University in Prague)</i>	
Experimental Study of Performance and Vulnerabilities of IEC 61850 Process Bus Communications on HSR Networks	584
<i>Stéphane Mocanu (Laboratoire d'Informatique de Grenoble, Univ. Grenoble Alpes, CNRS, Inria, Grenoble INP) and Jean-Marc Thiriet (GIPSA-Lab, Univ. Grenoble Alpes)</i>	
Network Fingerprinting: Routers under Attack	594
<i>Emeline Marechal (Montefiore Institute, Université de Liège, Liège, Belgium) and Benoit Donnet (Montefiore Institute, Université de Liège, Liège, Belgium)</i>	

SAD: Workshop on Software Attacks and Defenses

Defensive Programming for Smart Home Cybersecurity	600
<i>Maria Teresa Rossi (Gran Sasso Science Institute), Renan Greca (Gran Sasso Science Institute), Ludovico Iovino (Gran Sasso Science Institute), Giorgio Giacinto (University of Cagliari), and Antonia Bertolino (ISTI - CNR)</i>	
Resilient Self-Debugging Software Protection	606
<i>Bert Abrath (Ghent University), Bart Coppens (Ghent University), Ilja Nevolin (Ghent University), and Bjorn De Sutter (Ghent University)</i>	
Abusing Android Runtime for Application Obfuscation	616
<i>Pierre Gaux (CentraleSupélec, Inria, Univ Rennes, CNRS, IRISA), Jean-François Lalonde (CentraleSupélec, Inria, Univ Rennes, CNRS, IRISA), Pierre Wilke (CentraleSupélec, Inria, Univ Rennes, CNRS, IRISA), and Valérie Viet Triem Tong (CentraleSupélec, Inria, Univ Rennes, CNRS, IRISA)</i>	
Revealing Similarities in Android Malware by Dissecting their Methods	625
<i>Michele Pasetto (Università di Verona), Niccolò Marastoni (University of Verona), and Mila Dalla Preda (University of Verona)</i>	
Towards Formal Verification of Program Obfuscation	635
<i>Weiyun Lu (University of Ottawa, Canada), Bahman Sistani (Irdeto Canada), Amy Felty (University of Ottawa, Canada), and Philip Scott (University of Ottawa, Canada)</i>	

SecWeb: SecWeb 2020

SecWeb 2020 Preface	645
<i>Stefano Calzavara (Università Ca' Foscari Venezia) and Ben Stock (CISPA)</i>	
No Phishing with the Wrong Bait: Reducing the Phishing Risk by Address Separation	646
<i>Vincent Drury (RWTH Aachen University) and Ulrike Meyer (RWTH Aachen University)</i>	
Hardening Firefox against Injection Attacks	653
<i>Christoph Kerschbaumer (Mozilla Corporation), Tom Ritter (Mozilla Corporation), and Frederik Braun (Mozilla Corporation)</i>	
User Access Privacy in OAuth 2.0 and OpenID Connect	664
<i>Wanpeng Li (University of Aberdeen) and Chris J Mitchell (Royal Holloway, University of London)</i>	
Oh, the Places You'll Go! Finding Our Way Back from the Web Platform's Ill-Conceived Jaunts	673
<i>Artur Janc (Google, Inc) and Mike West (Google, Inc)</i>	

SILM: SILM Workshop on Security of Software/Hardware Interfaces

Preface of the 2nd Workshop on the Security of Software/Hardware Interfaces (SILM 2020)	681
<i>Guillaume Hiet (CentraleSupélec/Inria, IRISA), Frédéric Tronel (CentraleSupélec/Inria, IRISA), and Jean-Louis Lanet (Inria, IRISA)</i>	
Reverse Engineering the Stream Prefetcher for Profit	682
<i>Aditya Rohan (IIT Kanpur), Biswabandan Panda (CSE IIT Kanpur), and Prakhar Agarwal (IIT Kanpur/ Tower Research)</i>	
CHERI Macarons: Efficient, Host-based Access Control for Cyber-physical Systems	688
<i>Michael Dodson (University of Cambridge), Alastair R. Beresford (University of Cambridge), Alexander Richardson (University of Cambridge), Jessica Clarke (University of Cambridge), and Robert N. M. Watson (University of Cambridge)</i>	
NOP-Oriented Programming: Should we Care?	694
<i>Pierre-Yves Péneau (Univ Rennes, Inria, CNRS, IRISA), Ludovic Claudepierre (Univ Rennes, Inria, CNRS, IRISA), Damien Hardy (Univ Rennes, Inria, CNRS, IRISA), and Erven Rohou (Univ Rennes, Inria, CNRS, IRISA)</i>	
REHAD: Using Low-Frequency Reconfigurable Hardware for Cache Side-Channel Attacks Detection	704
<i>Yuxiao Mao (LAAS-CNRS, Université de Toulouse, CNRS, INSA, France), Vincent Migliore (LAAS-CNRS, Université de Toulouse, CNRS, INSA, France), and Vincent Nicomette (LAAS-CNRS, Université de Toulouse, CNRS, INSA, France)</i>	
Nethammer: Inducing Rowhammer Faults through Network Requests	710
<i>Moritz Lipp (Graz University of Technology), Michael Schwarz (Graz University of Technology), Lukas Raab (Graz University of Technology), Lukas Lamster (Graz University of Technology), Misiker Tadesse Aga (University of Michigan), Clémentine Maurice (Univ Rennes, CNRS, IRISA), and Daniel Gruss (Graz University of Technology)</i>	
Author Index	721