Project Acronym:	**TRESCCA**
Project Title:	Trustworthy Embedded systems for Secure Cloud Computing
Project number:	European Commission – 318036
Call identifier	FP7-ICT-2011-8
Start date of project:	01 Oct. 2012 **Duration:** 36 months

Document reference number:	**D5.8**
Document title:	Final Advisory Board report
Version:	1.3
Due date of document:	30. September 2013
Actual submission date:	01 November 2013 (Version 1.0) 13 November 2013 (Version 1.1) 14 October 2014 (Version 1.2) 03 November 2015 (Version 1.3)
Lead beneficiary:	OFFIS
Participants:	All

Project co-founded by the European Commission within the 7th Framework Programme		
DISSEMINATION LEVEL		
PU	Public	**X**
PCA	Public with confidential annex	
CO	Confidential, only for members of the consortium (including Commission Services)	

EXECUTIVE SUMMARY

TRESCCA has set up and integrated a Project Advisory Board (PAB) to receive feedback and influence the development and applicability of project results. The board is also meant to increase visibility and the impact to security and cloud computing community. This deliverable reports on the establishment and current status of the PAB. It documents the composition of the PAB including their membership history. Each member was selected by the consortium based on his/her expertise. The PAB consists of six members from different domains supporting TRESCCA in several areas of interest. Furthermore, it reports on feedback received during several technical meetings where PAB members participated. D5.2 has been considered as living document and always reflected the current state, activity and influence of the PAB. All this input finally led to the final version of this report D5.8.

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1 INTRODUCTION

1.1 Purpose of the Document

This document is deliverable "D5.8 - Final Advisory Board report" of the TRESCCA project. It has evolved from several iterations of deliverable D5.2. These deliverable iterations were considered as intermediate reports regarding the interaction and response integration of the TRESCCA Project Advisory Board (in the following PAB) within the TRESCCA project. The PAB itself consists of different domain experts and is also meant to increase visibility and the impact to security and cloud computing community. The deliverable D5.2 was intended to be the successor deliverable of the final deliverable "D5.8 Final Advisory Board report". Further, it was a living document, since it documented all PAB related activities, e.g. current state of membership, response, advices and the resulting impact on project decisions. The collected information was used to improve the development of TRESCCA, aligned to European legal aspects and impact the overall applicability of TRESCCA technology.

1.2 Document Versions Sheet

Version	Date	Description, modifications, authors
1.0	01.11.2013	Initial version.
1.1	13.11.2013	Correct information in 3.1.7 - Reasons for Usage of DES-X
1.2	10.06.2014	Add section for 2nd PAB meeting
1.3	03.11.2015	Add section for 3rd PAB meeting

2 Project Advisory Board

2.1 Introduction and Intention

TRESCCA has set up a technical and regulatory advisory board called Project Advisory Board (PAB). The intention of the PAB is to ensure the collection of feedback on its results. The goal is to integrate complementary expertise, to increase the impact to the security and cloud computing community. The board is integrated within the project research work-plan. The constitution of this Advisory Board enabled to involve both end-users and regulatory entities to ensure that the project results are aligned with the legal and regulatory European aspects and end-users needs. It also contributed to reduce the probability of the identified technical risk of not having end-users for the evaluation case studies. The PAB helped the consortium to formulate its objectives taking into account the concerns of different players, as well as many non-technical aspects that will have an impact to the acceptability and adoption of TRESCCA technology.

2.2 Members and Status

The advisory board consists of three sections: technical/industrial, research/industry and legal/business, collecting input provided by technical leaders from an end-user point of view and from regulatory entities and legal experts. The PAB consisted of six members shown in Table 1: PAB Organizations and Members

TRESCCA's consortium is anxious to maintain a good selection of PAB members representing a wide range of interests. Adjustments were always possible and were realised if necessary.

Section	Name	Position	Organization	Status
Legal/Business	Alexander Duisberg	Lawyer Partner	Bird&Bird Lawyers	established
Legal/Business	Daniele Catteddu	Managing Director EMEA	Cloud Security Alliance	established
Research/Industrial	Aljosa Pasic	Department Director	Atos - Research & Innovation	established
Technical/Industrial	Karim Khalfallah	ANSSI, SDE/ST/LSC	ANSSI - French Network and Information Security Agency	established
Technical/Industrial	Sibylle Fröschle	Associate Professor	Carl v. Ossietzky University of Oldenburg	established
Technical/Industrial	Petro Paglierani		Italtel S.p.A.	established

Table 1: PAB Organizations and Members

2.3 Membership History

This section documents the individual advisory board membership and the history in participation. It regards only the management related activities. The documentation is intended to reflect three issues. On the one hand it documents the details to contact partners and at least the effort made by TRESCCA partners to establish the Project Advisory Board. On the other hand it will possibly allow deriving an impression of the activity of each member in responding to the project demands.

2.3.1 ANSSI - French Network and Information Security Agency

The following address has been noted by OFFIS to official communication with:

ANSSI - French Network and Information Security Agency
51 boulevard de la Tour Maubourg,
75700 Paris 07 SP,
France

The involved contact person is:

Karim Khalfallah
karim.khalfallah@ssi.gouv.fr

The following history of activities can be listed

- Agreement of participation in March 2013
- Invitation to join the TRESCCA PAB by sending the official letters
- Signed NDA reached OFFIS
- Preparation of information regarding 2nd technical meeting submitted
- Introduction and presentation at 2nd technical meeting in Paris, France, October 2013
- Attendance at 5th technical meeting technical meeting in Paris, France, February 2015
- Attendance at 6th technical meeting in Sevilla, Spain, Junde 2015

2.3.2 Atos - Research & Innovationin

The following address has been noted by OFFIS to official communication with:

Atos SE
C. Albarracin 25,
28037 Madrid,
Spain

The involved contact person is:

Aljosa Pasic
Department Director
aljosa.pasic@atos.net

The following history of activities can be listed

- Agreement of participation in March 2013
- Invitation to join the TRESCCA PAB by sending the official letters
- Signed NDA reached OFFIS
- Preparation of information regarding 2nd technical meeting submitted

- No attendance at 2nd technical meeting in Paris, France, October 2013
- Aljosa Pasic replaces Fernando Kraus
- Attendance at 6th technical meeting in Sevilla, Spain, June 2015

2.3.3 Bird&Bird

The following address has been noted by OFFIS to official communication with:

Bird&Bird
Pacellisstr. 14,
80333 Munich,
Germany

The involved contact person is:

Alexander Duisberg
Lawyer & Partner
alexander.duisberg@twobirds.com

The following history of activities can be listed

- Agreement of participation in November 2012
- Invitation to join the TRESCCA PAB by sending the official letters
- Signed NDA reached OFFIS
- Preparation of information regarding 2nd technical meeting submitted
- Introduction and presentation at 2nd technical meeting in Paris, France, October 2013
- Attendance at 2nd PAB Meeting collocated with CSP Forum 2015 in Athens, Mai 2014

2.3.4 Cloud Security Alliance

The following address has been noted by OFFIS to official communication with:

Cloud Security Alliance
4 Melville Street,
Edinburgh,
Scotland, EH3 7HA,
United Kingdom

The involved contact person is:

Daniele Catteddu
Managing Director EMEA
dcatteddu@cloudsecurityalliance.org

The following history of activities can be listed

- Agreement of participation April 2013
- Invitation to join the TRESCCA PAB by sending the official letters
- Signed NDA reached OFFIS
- Preparation of information regarding 2nd technical meeting submitted
- No attendance at 2nd technical meeting a Paris, France, October 2013

2.3.5 Carl v. Ossietzky University of Oldenburg

The following address has been noted by OFFIS to official communication with:

Carl v. Ossietzky University of Oldenburg
Faculty II
Department of Computer Science
D-26111 Oldenburg
Germany

The involved contact person is:

Sibylle Fröschle
Associate Professor
sibylle.froeschle@informatik.uni-oldenburg.de

The following history of activities can be listed

- Face to Face introduction of TRESCCA at OFFIS, Oldenburg, Germany in July 2013
- Agreement of participation in August 2013
- Invitation to join the TRESCCA PAB by sending the official letters
- Signed NDA reached OFFIS
- Preparation of information regarding 2nd technical meeting submitted
- Introduction and presentation at 2nd technical meeting a Paris, France, October 2013
- No attendance at 5th technical meeting technical meeting in Paris, France, February 2015
- Attendance at 6th technical meeting in Sevilla, Spain, June 2015

2.3.6 Italtel S.p.A.

The following address has been noted by OFFIS to official communication with:

Italtel S.p.A.
Via Reiss Romoli
Località Castelletto
20019 Settimo Milanese (Milano)
Italy

The involved contact person is:

Pietro Paglierani
Senior DSP (Digital Signal Processing) System Engineer
pietro.paglierani@italtel.com

The following history of activities can be listed

- Agreement of participation in October 2013
- Invitation to join the TRESCCA PAB by sending the official letters
- Signed NDA reached OFFIS
- Attendance at 2nd PAB Meeting collocated with CSP Forum 2015 in Athens, Mai 2014

3 Conducted Activities

The Advisory Board is integrated within project work through multiple activities.

- Invitation to special sessions and internal workshops during project meetings.
- Regular phone and video conferences exchanging latest results and feedback.
- Face to Face or direct individual interviews with each PAB member in his field of expertise after the first review phase.

Conducted activities during the first project year were mainly focused on establishing the constitution of the PAB. This includes consortium agreement on selection of possible candidates, sending official invitation letters and exchanging non-disclosure agreements. The most valuable feedback from the PAB was received during the 2nd technical meeting at Paris. During the second project year a dedicated PAB session was held in Athens which was collocated with the CSP Forum 2014 and in the third project year PAB members were invited to join technical meetings of TRESCCA. Reasonable attendance was achieved during the 6th technical meeting in Sevilla where 3 PAB members were able to join the meeting.

3.1 Second technical Meeting

The second technical meeting of the TRESCCA consortium took place between 1st and 2nd of October 2013 in Paris. The second day was devoted exclusively to the PAB and three members were able to come. It is important to note that members of the PAB are doing their work on a voluntary basis. Therefore it cannot be expected to have all members always available and their work and feedback have to be appreciated properly. They were given the following material beforehand for preparation purpose:

- Project overview as slides
- Final version of Deliverable 1.1
- Interim version of Deliverable 1.3
- Description of work without financial information

During the meeting the whole project was presented in detail. This includes an overview presentation, summaries of finished deliverables in work package 1 and a detailed walkthrough of all work packages describing current state, future work and highlights of the first project year. Although PAB members were not yet very familiar with TRESCCA, they provided some valuable feedback and some fruitful discussion arose. At the end of the day, PAB members expressed their opinion that TRESCCA is an impressive project that sounds promising and the presentations were very illustrative and helpful to get an impression. The major points of discussion will be summarized in the following.

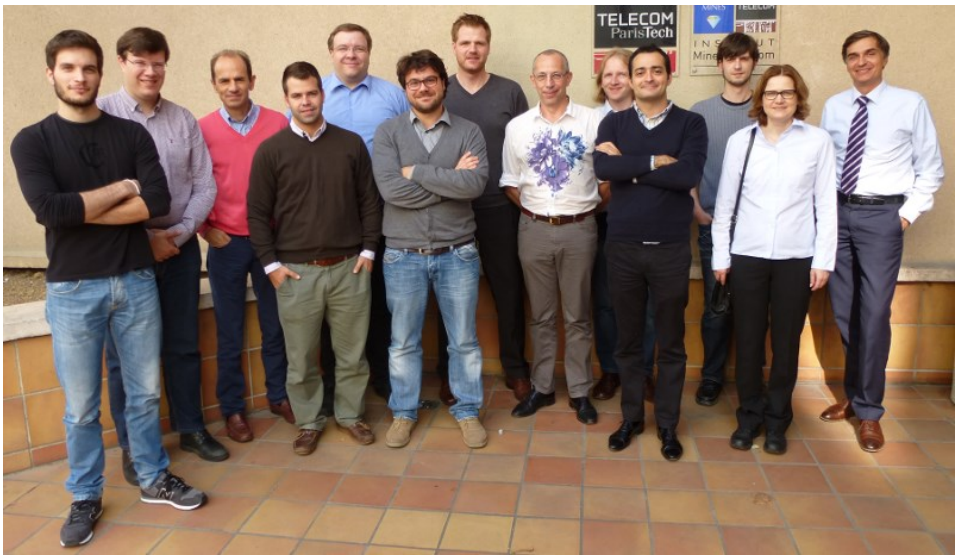

Figure 1: TRESCCA Consortium[1] and PAB at 2nd Technical Meeting in Paris, France.

3.1.1 Virtual Machine Migration

Task 3.3 deals with the ability of transferring virtual machines (VMs) between client and cloud which is called VM migration. The previous day there was already a lot of discussion about technical aspects of this approach. Expectedly, this topic triggered a long discussion about technical and legal issues. Besides all technical boundaries, from a legal point of view it would be a radical change if it was possible to have only one copy of an asset like in real world scenarios. It is important to note that this is only possible if VMs really are moved reliably, not copied in a classical sense. This could affect copyright issues of electronic content as well as establish new markets to resell digital products. Besides introduced overhead of this approach on the technical side, there arose questions like how to create assurance of the fact that something was deleted. Software and data has to be coupled tightly together which would allow to ship data together with the software needed to consume it. The most illustrative example is an e-book scenario where the VM would be the book together with the reader application. Instead of using client-server solutions and protocol-based communication, it could create a new paradigm for application development which has the potential of being much simpler.

3.1.2 Device Integration

Work package 2 deals with the development of the Hardware Security Module (HSM) which provides process isolation and memory protection. The discussion was about how a HSM could be integrated into production systems. The HSM is first of all a piece of hardware integrated into the System on Chip (SoC). This should clearly be pointed out because many people call the whole chip HSM. To integrate TRESCCA's HSM into smart phones for example, vendors have to be convinced to integrate this into their devices. The general conclusion to encourage adoption of TRESCCA technology is to be as open as possible. Design and drivers of HSM will be open source and manufactures are free to use them. This will be different from today, as they are having proprietary technology and pay quite some money to integrate third party add-ons. Additionally, HSM is independent of chosen CPU, it does not even need to be ARM technology at all.

[1] From left to right: Alvise Rigo, Guillaume Duc, Marcello Corpolla, Ignacio Garcia Vega, Andreas Herrholz, Michele Paolino, Gunnar Schomaker, Renaud Pacalet, Christian Steno, Karim Khalfallah , Bernhard Katzmarski, Sybille Fröschle, Alexander Duisberg

Figure 2: PAB meeting presentation session during 2nd Technical Meeting[2].

3.1.3 Evaluate Tamper Resistance

The HSM is often compared to the Trusted Platform Module, therefore the question arose on how tamper resistant the HSM could be and how this could be evaluated. It had to be pointed out that TRESCCA is not dealing with tamper-proof hardware construction and integration; TRESCCA is rather doing modular security and excludes certain threats such as fault or side channel attacks. Other technology has to be used to deal with uncovered issues. The HSM will offer process isolation and external memory protection as an enabling technology and will be as compatible as possible with other protection mechanisms to deal with other threats. Attacking external memory is the most common approach for part time hackers. The risk of this scenario is much higher and protection against these kinds of attacks will bring a lot of benefit. These protections are getting more and more important because home boxes are simply to be exploited by codes found on the internet.

3.1.4 Threat Model and Secure Boot

Task 1.1 deals with the security analysis of cloud applications and specification of security objectives. This task resulted in the deliverable D1.1 which establishes the security objectives and the threat model of the TRESCCA platform. The developed threat model includes adversaries that have full access to client devices except the internals of the main SoC. The question arose if it will be contradictory to have a secure boot on the one hand and a threat model including adversaries who have complete physical access to light client hardware and are able to run arbitrary applications. It has to be ensured that the SW driver configures the HW properly and that itis a genuine one. Due to HW and SW isolation itis possible to overcome the threat of adversaries tampering with their devices. It even reduces the motivation to exploit a device for running third party software, as they are allowed to do so anyway. Only trusted parts of the TRESCCA stack need to be protected properly by using secure boot mechanism.

3.1.5 Smart Card Performance

Most of TRESCCA's application domains lack HW security solutions or are not applicable for realizing projects objectives. On PC environments that come with untrusted hardware and software only secure boot or TPM could be used. In the embedded systems world, only proprietary solutions are available and a general lack of standards is present. Smart cards introduce a high level of security but are not applicable for more complex systems due to performance constraints. One objection from the PAB here was that performance constraints of smart cards are due to resistance against intrusion and tampering. The encryption of memory would degrade the performance more than counter measures of

[2] From left to right: Alexander Duisberg, Sybille Fröschle, Bernhard Katzmarski, Renaud Pacalet

smart cards. In fact the HSM introduces overhead by encrypting memory pages but the target systems are also much larger. TRESCCA is targeting systems with GHz CPUs and gigabytes of memory which smart cards cannot handle. Smart cards may be a good starting point but elaboration on them is limited. Additionally it is possible to reduce encryption overhead by only applying it on necessary memory pages that contain sensitive information. Compared to a TPM which is indeed very secure, all data incoming or leaving are not secure anymore. In fact, a TPM could be built on top of the TRESCCA platform which makes pure HW based TPM solutions obsolete. But this surely depends on the use case. Regarding the costs, putting TPM inside SoC would be more expensive. But if only a TPM is necessary, it will still be cheaper to go with the exclusive hardware solution.

3.1.6 Denial of Service Detection

A Protection Security Unit (PSU) for virtualization supports strong VM isolation by tagging Network on Chip (NoC) transactions, establishing access rules, ensuring rules are obeyed and a cache hierarchy for scalable and fast access. By placing a PSU at each initiator Denial-of-Service (DoS) attacks can be detected. Massive unauthorized access cannot saturate the NoC. This has created some discussions within the PAB; it had to be made clear that denial-of-service attacks can theoretically be detected and subverted if rule-based protection (PSU) is installed at the network interface of the initiator. However, the effectiveness depends on the precise architecture and needs to be explored. The definition and evaluation of interference metric to other VMs could be considered but further investigation is needed.

The question arose if it is planned to include more complex rules like an executable permission. Indeed, more rules are considered but unfortunately, rule checking has to be close to the architecture. Linux systems have different types of implementations for these rule-based permission systems that cannot be addressed generically.

3.1.7 Reasons for Usage of DES-X

The first evaluation prototype of the HSM uses DES-X algorithm for encryption and integrity checking of external memory. The reasons for choosing DES-X had to be explained in more detail: DES is not considered because it is obsolete nowadays. DES has got much smaller key space for the same computation cost. DES-X can overcome this with a much larger key space. However, it is important to state that DES-X is just one possible choice which covers all use cases. Exchanging the algorithm would not change the principles of the HSM-mem. DES-X has been chosen for TRESCCA as a trade-off between cost, speed and security. For game consoles or set top boxes it is a very logical choice. Other algorithms like AES would be preferable for high-end systems like servers in data centers.

3.2 2nd PAB Meeting Collocated with CSP Forum Conference 2014

The 2nd Meeting with the Advisory Board took place in Athens on 22nd of Mai 2014. It was collocated with the annual CSP Forum Conference. The project acquired a 2 hour workshop at the conference and several partners gave interesting presentations. All members of the PAB were invited to join the workshop and the subsequent meeting. This approach was very meaningful, because in this way PAB members firstly got an overview about technical development going on in TRESCCA by attending the workshop. During the 4 hours meeting current status, highlights, achievements and next steps were presented. Additionally, some early prototypes were demonstrated to the PAB members. Afterwards, a dedicated discussion within the PAB members during the meeting was possible. Although five members declared their willingness to join the meeting, in the end only three members were present because of unexpected diseases or other obligations. However, the discussion with the members was again very fruitful and discovered several topics the consortium has to consider.

During the meeting Dr. Alexander Duisberg gave an interesting talk about **data protection and data transfers in the cloud**. As a lawyer, he was able to explain legal aspects of cross-border data protection and exchange on an European level.

Figure 3: Consortium and PAB members at 2nd PAB meeting[3].

3.2.1 Homomorphic encryption

TRESCCA is addressing the challenge to protect integrity and confidentiality of data. Certainly, encryption is the only reasonable way to achieve this. But this approach is only useful as long as only storage is needed. For processing, data needs to be decrypted which creates potential for leakage and spying. Unsurprisingly, the question came up very early why TRESCCA is not using homomorphic encryption to operate directly on encrypted data. This would solve the issue to protect data in remote processing but unfortunately current approaches are still on its infancy. Indeed, related research shows that homomorphic encryption is possible but due to computational overhead it is still not practical.

3.2.2 Configuration of Firewalls

The NoC-Firewall is the essential extension to improve isolation of virtual machines. The important point to consider is who and when decisions about the necessary policies are made. The concept is mainly about specifying deny rules but somebody has to decide which communication is allowed and which should be blocked. Due to the dynamic environment, a secure storage location for these rules is mandatory which also supports dynamic changes of policy tables. Currently, the use of NoC-Firewall is not meant to be visible to the end user itself. Some vendor or authority needs to build and ship the necessary rules.

3.2.3 Software to Data

During the talk about data protection, a lot of reference to the VM migration concept came up. It is noticeable, that the approach where software comes to data is amazingly strong related to current data protection regulations. The shared responsibility for data controllers and data processors is an emerging field which will require more technical support in the future. All contracting parties are

[3] From left to right: Gunnar Schomaker, Andreas Herrholz, Jérémie Brunel, Alexander Duisberg, Michele Paolino, Pietro Paglierani, Bernhard Katzmarski, Kyprianos Papadimitriou

responsible for their side of the processing and if anything goes wrong, the guilty one can directly be identified. More openness and transparency are steps ahead and TRESCCA supports this progress by hardening local devices and the possibility to delegate processing to remote sides.

3.2.4 Integration challenge

TRESCCA's solution consists of different components that are currently under development and partially available as early prototypes. It was advised by the PAB to urge to integration as soon as possible. It is a very critical part in which way the different pieces could be put together for a prototype. It was suggested to use a vertical integration approach and also delegate responsibilities for the integration part. Additionally, the validation phase is not yet fully planned but this will be addressed mainly in work package 4.

3.3 3rd PAB Meeting

The 3rd Meeting with the Advisory Board took place in Sevilla on 24th of June 2015. The TRESCCA consortium held its 6th Technical Meeting from 24th to 26th of June on the premises of Wellness Telecom and the PAB members were invited to join this meeting on the first day. Three members were able to come and all of them have been present at previous meetings before. This fact reduced the introduction session and members of the technical committee could almost immediately present their recent developments. Like in the meetings before, discussion with the PAB was fruitful and major points will be summarized in the following.

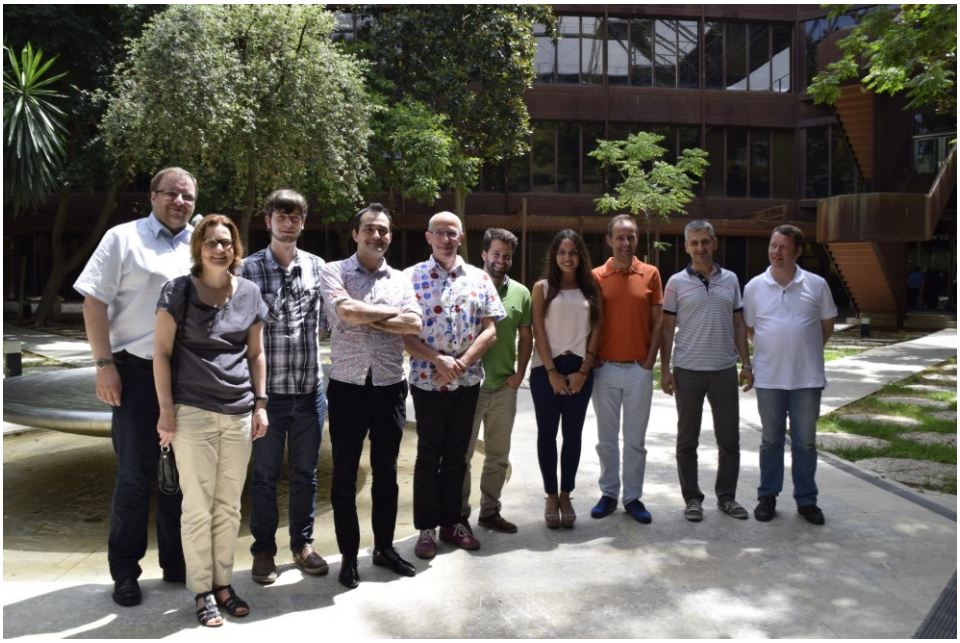

Figure 4: Consortium and PAB members at 3rd PAB meeting[4]

[4] From left to right: Andreas Herrholz, Sybille Fröschle, Bernhard Katzmarski, Karim Khalfallah, Renaud Pacalet, Ignacio Garcia Vega, Mercedes Castano Torres, Aljosa Pasic, Kyprianos Papadimitriou, Sebastian Gentzen

Figure 5: Demo session during the 6th Technical Meeting in Sevilla

3.3.1 Exploitation of TRESCCA components

Members of the PAB were asking how components like the HSM-Mem or HSM-NoC will be exploited. Especially, which companies would integrate and use these technologies in their next generation chips? STMicroelectronics as a member of the consortium is a potential candidate but companies like Huawei EADS or Thales already indicated interest. But it will take several years until some TRESCCA results are available in consumer products as hardware design and manufacturing is a process with large time frames.

3.3.2 Similar technologies on the market

ARM's Trustzone is similar to HSM-NoC developed in TRESCCA. External smart cards are an alternative the HSM-Mem technology but they do not offer as much processing power. Smart cards are generally useful to provide confidentiality and integrity at boot time needed for on-chip security and could be used complementary.

3.3.3 Formal verification

There was an interesting discussion about formal verification regarding different aspects starting with the question if formal verification has been done for HSM-Mem. Generally, it is a hard and time-consuming task but for some parts these verifications are available. This immediately led to the question of state of the art in formal verification, where Sybille Fröschle could give some insights. It is theoretically possible but a matter of time. Aspects like parallel development and lack of good specification can be obstacles. Tools like SCADE are available in the safety field but we seem to be missing similar tools for the security domain.

3.3.4 Attack vectors

One PAB member wanted to know if well-known attacks like buffer overflow, libc return or side channel attacks are covered by TRESCCA. Generally, components of TRESCCA do not protect against software flaws. TRESCCA is serving building blocks to protect against well-chosen attacks like bus probing protection of HSM-Mem. The responsibility of correct configuration is out of scope for the project. Good tools are not everything and they do not help if they are misused. However, this discussion demonstrated that a global explanation or presentation is required to build up the big picture to provide outside people a more precise idea of what TRESCCA is offering. Similar questions such as side channel attacks or physically uncloneable functions (PUFs) are asked every time. To start

a presentation of TRESCCA with an example, then illustrate market demand and show what benefit TRESCCA provides, should be a good approach to follow.

4 CONCLUSION

The main goal of this deliverable is to document the show how TRESCCA has spent effort to receive feedback from the PAB. It provides an overview of the member activities and shows the discussion topics and issues discovered by the members of the PAB. The collected information has been valuable to improve the overall quality of TRESCCA.

During all three meetings the members of the board provided an objective outside view on what the project had achieved so far and was further planning to do during the remaining duration of the project. While no significant issues were risen, many questions asked by the board revealed deficits in the way the project explained its objectives and results to the public. Following the board's recommendations, the project could improve its dissemination activities and general visibility significantly.

Also the board reminded the Consortium several times to collaborate on an integrated prototype to end the project with a convincing demonstration of what can be achieved with all TRESCCA components integrated. As a result, the Consortium developed an integrated prototype integrating and demonstrating all components within one client platform.

One objective that could not fully be achieved through the PAB is the integration of end-users and their perspective on TRESCCA technology. This is mainly due to two main issues:

1. The outcomes of TRESCCA are base technologies and components for integration and no end-user products on its own. The demo applications developed in the project are proof-of-concepts but no actual product prototypes yet. It would be up for a follow-up project or individual exploitation plans of Consortium members to come up with an end-user product based on TRESCCA results that is ready for end-user evaluation.

2. The setup of the PAB was done as a follow-up action to a Commission request during negotiation phase but after the initial proposal and budget planning. Therefore budget for this action was limited to face-to-face meetings. In a follow-up project, the PAB should be included from the start and provided with sufficient budget to do meetings as well as more interactive reviews and evaluation of project results.

Nonetheless, the Project Advisory Board proved to be a valuable addition to the TRESCCA Consortium and helped to define and shape the research directions of the project.