OF@TEIN+:
Open/Federated Playgrounds for Future Networks

Building and operating Open and Federated Future Internet
(SDN/NFV/Cloud-integrated) Testbed

This proposal is prepared in response to Asi@Connect WP4 (Future Internet)

Proposed by

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1 Executive Summary

This proposal is prepared in response to Asi@Connect WP4 (Future Internet) grant support calling. This document describes the proposed project of "OF@TEIN+: Open/Federated Playgrounds for Future Networks" for the period of 60 months (5 years), which will leverage and enhance the successfully completed OF@TEIN project. As a start, we are seeking for grant support for the first 22 months. (March 2017 – December 2108)

Primary goals of this project are:

1. Gather and Learn Together: Expanding the OF@TEIN Community and Sharing the Knowledge about Open and Federated (i.e., shared) SDN/NFV/Cloud-integrated Playground amongst the Members.
2. Build and Upgrade Together: Deployment and Upgrade of Open/Federated Playground with Distributed SmartX Box Playground Resources and Centralized Data Lake/Analytics Hardware.
3. Operate and Automate Together: Collaborate among Leading Members to enable Automated DevOps-style Operation of Playground Resources and Platforms.
4. Play and Visualize Together: Collaborate with All Members in Experimenting (i.e., Playing) and Visualizing "Plays over Playground".
5. Investigate and Enrich Together: Investigate selected building-block topics on Future Network technology and attempt to enhance the playground capability/agility by applying the investigation outcomes.

OF@TEIN: Toward an OpenFlow-enabled SDN (Software-Defined Networking) Infrastructure over TEIN – was one of e-TEIN projects sponsored by Korean Government via NIA (National Information Agency), launched in July 2012 and led by Prof. JongWon Kim from NetCS (Networked Computing Systems) Laboratory, GIST (Gwangju Institute of Science & Technology), Korea. This project has completed successfully with many success stories have been achieved by the collaborators. For example,

a) An overlay virtualized OpenFlow-enabled SDN testbed over 12 international sites;
b) Open and wide availability of state-of-the-art distributed SDN-Cloud testbed facility;
c) Co-authored publications in high impact journals and conference proceedings;
d) Dedicated knowledge-sharing workshops conducted annually in Malaysia, Thailand and Vietnam;
e) Students and professors' mobility between collaborators;
f) Incubated joint researches among project partners to work closely and improve research quality and impact;
g) Contributed to the creation of APAN Cloud WG (and to-be-established Cloud TF) to promote the cloud-based computing/storage sharing among TEIN community.

As OF@TEIN project has completed with many success stories, "OF@TEIN+: Open/Federated Playgrounds for Future Networks" is proposed to further enhance, extend and expand OF@TEIN. The main purpose of OF@TEIN+ is to build and operate an Open and Federated Future Internet (SDN/ NFV/Cloud-integrated) Testbed in further promoting SDN-Cloud R&D collaboration among TEIN partners.

In order to bring OF@TEIN+ to a greater height, a project team with members from every collaboration country has been formed. The project team (to be expanded to include more Asi@Connect connected countries) is as follow:

Co-PI: Teck Chaw Ling, PhD (University of Malaya, Malaysia) (**Corresponding-PI**)
Co-PI: JongWon Kim, PhD (GIST, Korea)
Team members:
Aung Htein Maw, PhD (UCSY, Myanmar)
Chaodit Aswakul, PhD (Chulalongkorn University, Thailand)

Chu-Sing Yang, PhD (National Cheng Kung University, Taiwan)
Chun-Yong Chong (Monash Malaysia, Malaysia)
Đinh Văn Dũng, PhD (VNU, Vietnam)
Jiann-Liang Chen, PhD (NTUST, Taiwan)
Khamxay Leevangtou (NUOL, Laos)
Muhammad Tayyab Chaudhry, PhD (CIIT, Lahore, Pakistan)
Nguyen Huu Thanh, PhD (HUST, Vietnam)
Panjai Tantatsanawong, PhD (UNINET, Thailand)
Paventhan Arumugam, PhD (ERNET, India)
Su Thawda Win, PhD (UCSM, Myanmar)
Sunyoung Han, PhD (Konkuk U, Korea)
Te-Lung Liu, PhD (NCHC, Taiwan)
Wangcheol Song, PhD (Jeju University, Korea)

The project team will ensure the aims and goals of OF@TEIN+ are achieved according to current best practices.

At the end of the project (22 months), the below goals will be achieved:

1. **Gather and Learn Together:**
   i. Annual meeting #1 **(Kuala Lumpur)**: Deliver training for accessing the playground through access center and access boxes for all members (**up to 20 international participants**)
   ii. Annual meeting #2 **(Bangkok)**: Deliver training for utilizing initial shared DataLake for all members (**up to 48 international participants**)
   iii. Collaboration Workshop #1 - Co-located with APAN 44: Management planning, meeting and Deliver training for ambassador (**up to 9 participants**)
   iv. Collaboration Workshop #2 - Co-located with APAN 45/46: Management planning, meeting and Deliver training for ambassador (**up to 18 participants**)
   v. Ambassador Programs: ambassador (**up to 15**) for promoting/installing/maintaining/ monitoring/training the boxes.
2. **Build and Upgrade Together:**
   i. Access Center Deployment: Providing (***up to 20***) virtual desktops for high-speed developers
   ii. Access Box Deployment: Providing dedicated lightweight desktops (**up to 12**) for low-speed/ isolated developers
   iii. SmartX Box Upgrade: boxes upgrade (**up to 8 sites**) and new installation (**up to 2 sites**)
3. **Operate and Automate Together:**
   i. Establishment of operational mailing-list and operational ticketing systems
   ii. Establishment of Initial DataLake for site-to-site Inter-Connection troubleshooting
   iii. Establishment of High-availability DataLake (**up to 2 sites**) for joint operation troubleshooting (underlay and overlay playground)
4. **Play and Visualize Together:**
   i. Developers (**up to 22 groups**) from all the community members to propose their experiments or to develop visualizations
   ii. Students (**up to 6**) for actively proposing new solutions to be deployed in the playground
5. **Investigate and Enrich Together:**
   i. Enhancing SDX-based deployment: Solutions/designs/plans (**up to 2**) to be deployed
   ii. Initial deployment of SOC: Deployment sites (**up to 3 sites**) for initial security collection

2. Purpose

The purpose of this proposal is to outline the various work items and associated resources required to undertake the project in response to Asi@Connect WP4 (Future Internet).

This document captures the following information:

- Background
- Project Partners and Team Members
- Project Motivation, Goals and Challenges
- Program of Works and Timeline
- Project Budget

3. Background

OF@TEIN: Toward an OpenFlow-enabled SDN (Software-Defined Networking) Infrastructure over TEIN is one of e-TEIN projects sponsored by Korean Government via NIA (National Information Agency), launched in July 2012. The project was led by Prof. JongWon Kim from NetCS (Networked Computing Systems) Laboratory, GIST (Gwangju Institute of Science & Technology) Korea.

The main objective of OF@TEIN collaboration was to deploy a shared OpenFlow-based SDN testbed infrastructure among Korea, South-East Asia and South Asia collaborators over TEIN4. The collaborators from South-East Asia are HUST @Hanoi, Vietnam; ASTI @Manila, Philippines; Chulalongkorn University @Bangkok, Thailand; ITB @Bandung, Indonesia; University of Malaya @Kuala Lumpur, Malaysia; MYREN NOC @Cyberjaya, Malaysia and from South Asia is PERN @Islamabad, Pakistan. In detail, a virtualized OpenFlow-enabled SDN testbed is built and operated over 7 International sites (Philippines, Indonesia, Thailand, Malaysia (2), Vietnam, Pakistan), and 5 sites in Korea (GIST @Gwangju; Korea U. @Seoul; KOREN-NOC@Seoul; Postech @Pohang; Jeju U. @Jeju). Mutual OF@TEIN collaboration MoUs (memo of understanding) between GIST and all partner institutes have been signed.

This project has completed successfully at the end of 2015. The completed SDN Testbed diagram of OF@TEIN infrastructure, built through the collaborative effort of OF@TEIN partners, is depicted below:

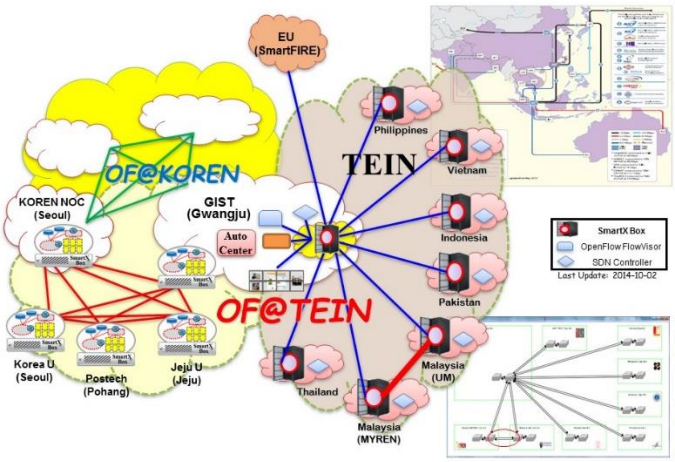
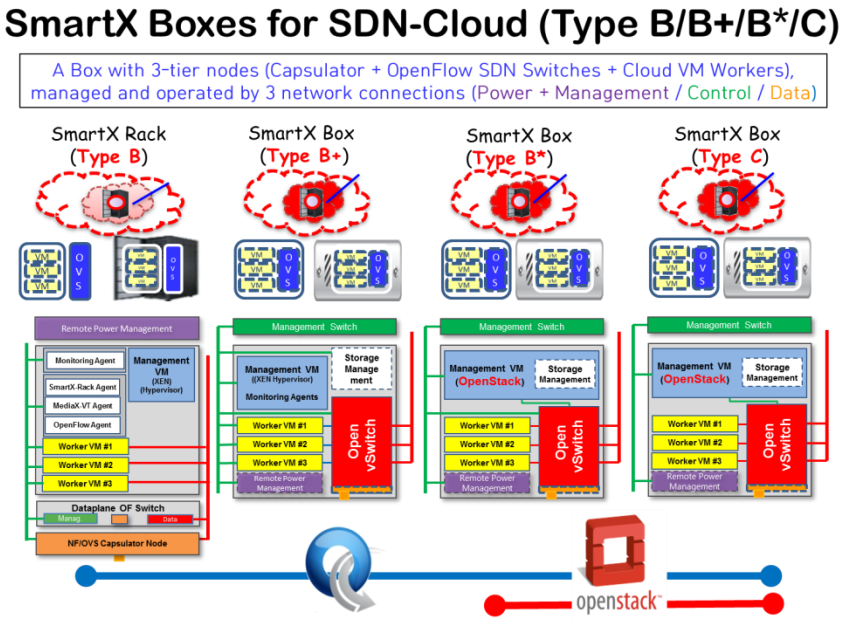


Figure 1: OF@TEIN infrastructure

In this project, a unique hyper-convergent SmartX Box (aka SmartX Rack) is designed and deployed in each site to promote the international SDN research collaboration over TEIN4 network infrastructure. There are five types (Type A/B/B+/B*/C) of unique SmartX Boxes being built for physical/virtual nodes

for OpenFlow Switches, Capsulators, and VM (virtual machine) Workers. In 2014, all international sites have been upgraded to unified SmartX Boxes (Type B+) and the five Korean sites have been upgraded to SmartX Boxes (Type C) for OpenStack integration. As of May 2015, all SmartX Boxes (Type B+) have been upgraded to Type B*, which accommodates improved OpenStack-based Cloud support.



Many success stories have been achieved by this project: A) An overlay-based virtualized and distributed OpenFlow/OpenStack-enabled SDN-Cloud testbed over 12 sites, which is unique in the view of world-wide efforts for Future Internet testbeds from US GENI and EU FIRE. B) Academic publications in high impact journals and conference proceedings (GIST, UM, Chula, HUST, NUST). C) Knowledge sharing workshops conducted in Malaysia (February 19-20, 2013); Bangkok, Thailand (March 20 – 22, 2014) and Hanoi, Vietnam (May 14-16, 2015). D) Professors and students mobility between collaborators (GIST-UM, GIST-Chula, GIST-NUST) and E) Researchers from different countries have been working closely and produced high quality research results.

As OF@TEIN project has completed with many success stories, "OF@TEIN+: Open/Federated Playgrounds for Future Networks" is proposed to further enhance, extend and expand OF@TEIN. The main purpose of OF@TEIN+ is to build and operate an Open and Federated Future Internet (SDN/ NFV/Cloud-integrated) Testbed in further promoting SDN-Cloud R&D collaboration among TEIN partners.

4. Project Partners and Team Members

Project partners from OF@TEIN will continue to participate in OF@TEIN+. These partners are:

1. Hanoi University of Science and Technology, Vietnam
2. Chulalongkorn University, Thailand
3. University of Malaya, Malaysia
4. MYREN NOC, Malaysia
5. Monash Malaysia, Malaysia
6. Institut Teknologi Bandung, Indonesia
7. PERN, Pakistan
8. GIST, Korea (Non-beneficially country)
9. Korea University, Korea (Non-beneficially country)
10. KOREN-NOC, Korea (Non-beneficially country)

11. Postech, Korea (Non-beneficially country)
12. Jeju National University, Korea (Non-beneficially country)

Apart from the above list, the following institutes have agreed to join OF@TEIN+ and an open call will be made to Asi@Connect community to recruit more partners that are qualified (Maximum total members: 40 (30 from beneficially countries + 10 non-beneficially):

13. COMSATS Institute of IT (CIIT), Lahore, Pakistan
14. University of Computer Studies, Yangon, Myanmar
15. University of Computer Studies, Mandalay, Myanmar
16. University of Information Technology, Yangon, Myanmar
17. National University of Laos, Laos
18. Vietnam National University, Vietnam
19. UNINET, Thailand
20. Hong Kong University, Hong Kong (Non-beneficially country)
21. Konkuk University, Korea (Non-beneficially country)
22. National Central University, Taiwan (Non-beneficially country)
23. National Taiwan University of Science and Technology, Taiwan (Non-beneficially country)
24. National Center for High-Performance Computing, Taiwan (Non-beneficially country)

In order to enhance, extend and expend the project, a project team with members from every collaboration country has been formed. The project team (to be expanded to include more Asi@Connect connected countries) is as follow:

Co-PI: Teck Chaw Ling, PhD (University of Malaya, Malaysia) (**Corresponding-PI**)
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Te-Lung Liu, PhD (NCHC, Taiwan)
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The project team will ensure the aims and goals of OF@TEIN+ are achieved according to the current best practices.

5. Project Motivation and Goals

As presented in the project partners section, the partners of OF@TEIN+ can be divided into three different economy types. Korea and Taiwan are from developed country, whereas from developing countries are India, Indonesia, Malaysia, Philippines, Thailand, Vietnam, and Pakistan. From least developed countries are Laos and Myanmar. This is an important attempt in resource sharing and research collaboration across 3 different economy types. As such, the motivations of this project are as follow:

1. **Cloud enables economical & flexible shared cyber-infrastructure:** Cloud represents the future paradigm of on-demand access to converged/virtualized (in terms of compute/networking/ storage) resources, shared data and information, and a usage-based billing model. Thus, based on cloud infrastructure/platform/software as a service, diverse services could be easily and economically realized in most academic, government and industry sectors.
2. **DevOps (Development & Operation) paradigm enables automated remote operation**: The total cost of ownership will be significantly reduced due to the emergence of SDN/NFV/Cloud integration. This technology shift is the key driver to manage an appropriate-sized resource pool for cloud-leveraged infrastructure, which can suits the current and future computing/storage demands of TEIN community.
3. **Asi@Connect NRENs enjoy network-based sharing of high-cost computing/storage resources:** Easy resource sharing among partners for both HPC (High Performance Computing) servers and large-capacity DataLake (file/object storages) will enhance ROI, research outcomes and outputs will increase in both quantity and quality.
4. **OF@TEIN collaboration can provide an excellent foundation for OF@TEIN+**: The collaboration experience and human networking of OF@TEIN collaboration project (2012~2015) can provide an excellent foundation for this community-driven open collaboration effort.
5. **APAN Cloud WG can provide both technical supports and operation expertise:** The new APAN Cloud WG (working group) and associated Cloud TF (task force) can provide technical expertise to build and operate a shared OF@TEIN+ SDN-Cloud and DataLake facility.

With a strong collaborative experience of OF@TEIN partners working together, the following goals are put in place for OF@TEIN+ while addressing several targeted technical challenges:

1. Gather and Learn Together: Expanding the OF@TEIN Community and Sharing the Knowledge about Open and Federated (i.e., shared) SDN/NFV/Cloud-integrated Playground amongst the Members.
2. Build and Upgrade Together: Deployment and Upgrade of Open/Federated Playground with Distributed SmartX Box Playground Resources and Centralized Data Lake/Analytics Hardware.
3. Operate and Automate Together: Collaborate among Leading Members to enable Automated DevOps-style Operation of Playground Resources and Platforms.
4. Play and Visualize Together: Collaborate with All Members in Experimenting (i.e., Playing) and Visualizing “Plays over Playground”.
5. Investigate and Enrich Together: Investigate selected building-block topics on Future Network technology and attempt to enhance the playground capability/agility by applying the investigation outcomes.

6. Program of Works and Timeline

This proposed project is meant for 22 months. The preliminary tasks are:

[Task #1 - Gather and Learn Together, M1-M22] Expanding the OF@TEIN Community and Sharing the Knowledge about Open and Federated (i.e., shared) SDN/NFV/Cloud-integrated Playground amongst the Members.

1 – 1 [M1 – M22] Recruit new **community members** (up to 24 members) and encourage existing members to become active/leading members including selecting **community ambassadors** to spread (advertise and teach) the idea of playground-based open collaboration. Also prepare relevant **online/offline training materials** for all community members.

1 – 2 [M1 – M22] Organize **collaboration community events including annual training workshops and meetings** (possibly co-located with Asi@Connect/APAN community meetings) for exchanging the research idea and sharing the knowledge amongst the community members especially in how to build, operate, play, and investigate shared playground for research collaboration.

1 – 3 [M1 – M22] **Coordinate project execution and support the handling of financial and administrative issues**. Also facilitate community member mobility (e.g., exchange students/researchers, internship programs, and visiting scholars).

[Task #2 - Build and Upgrade Together, M1-M22] Deployment and Upgrade of Open/Federated Playground with Distributed SmartX Box Playground Resources and Centralized Data Lake/Analytics Hardware.

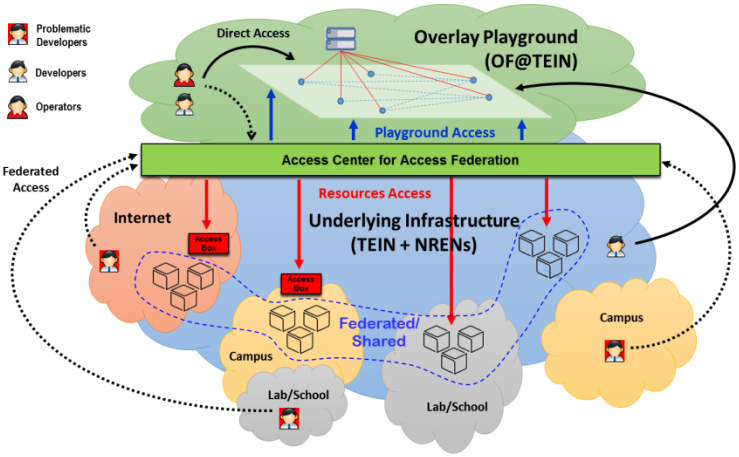
2 – 1 [M1 – M22] Extend the deployment and upgrade of distributed **SmartX Box playground resources** in more diversified types (e.g., Type B/B^{+}/B*/B**/B$^{\#}$ and others to support SDN/NFV/Cloud integration) and at more member sites (up to 10 sites). This will enhance the proposed playground to suit for both typical SDN/NFV/Cloud-integrated experimentations and advanced Future Network technology experimentations. Also help several problematic member sites (e.g., low-speed or isolated from R&E network) to access the playground through **Access Center** and **Access Box**.

2 – 2 [M13 – M22] Deploy and upgrade uniquely-designed **Data Lake/Analytics hardware** to enable the sharing of operation/experimentation visibility data and the BigData-based analysis on the shared data. It will be deployed at a member site in a beneficiary country (e.g., Malaysia Research Network Operation Center – MYREN NOC) and will be backed up by existing hardware in Korea (i.e., Gwangju Institute of Science and Technology - GIST).

[Task #3 - Operate and Automate Together, M1-M22] Collaborate among Leading Members to enable Automated DevOps-style Operation of Playground Resources and Platforms.

3 – 1 [M1 – M22] Establish the leading member coordination **to jointly operate** open/federated playground and cover various **troubleshooting/support interactions** with both underlying network infrastructure administrators (i.e., NREN/TEIN NOCs) and experimentation players.

3 – 2 [M7 – M22] Convert existing playground operation experience into DevOps-style automated operation by **jointly designing and developing platform and tools** for playground operation (e.g., provisioning/visibility/orchestration).



[Task #4 – Play and Visualize Together, M1-M22] Collaborate with All Members in Experimenting (i.e., Playing) and Visualizing "Plays over Playground".

4 – 1 [M1 – M22] Develop **typical and advanced plays (i.e., experimentations)** with all the members by utilizing the proposed playground. It will be coordinated via an open call for play experiments to the community members.

4 – 2 [M7 – M22] **Jointly develop various visualization tools** to better understand the details of underlay playground infrastructure (e.g., configuration and resource status). Also work together to enable flexible playground (including Data Lake/Analytics) access through Access Center.

[Task #5 - Investigate and Enrich Together, M1 – M22] Investigate selected building-block topics on Future Network technology and attempt to enhance the playground capability/agility by applying the investigation outcomes.

5 – 1 [M1 – M22] **Software-Defined Exchange (SDX) Investigation** by expanding SD-Routing-Exchange (i.e., Routing-based SDX) with additional new sites for further verification and establish joint operation with playground infrastructure network administrator. Besides, future-network exchange technologies (i.e., L3-SDX, Software Define Internet Exchange) which matched with federated playground requirements will also be investigated.

5 – 2 [M1 – M22] **SD-Security with Security Operation Center (SOC) Investigation** by building a shared platform to exchange important information (i.e., service status and system security) amongst all playground collaborators. Hence, the Security Operation Center is established to inspect the analysis results from DataLake, aggregate the results, and present the views the security aspect of the playground such as anomaly detection, security warning, and vulnerabilities attack.

7. Project Deliverables and Milestones (22 months)

At the end of the project (22 months), the below goals will be achieved:

1. Gather and Learn Together:

i. Annual meeting #1 **(Kuala Lumpur)**: Deliver training for accessing the playground through access center and access boxes for all members (**up to 20 international participants**)

ii. Annual meeting #2 **(Bangkok)**: Deliver training for utilizing initial shared DataLake for all members (**up to 48 international participants**)
iii. Collaboration Workshop #1 - Co-located with APAN 44: Management planning, meeting and Deliver training for ambassador (**up to 9 participants**)
iv. Collaboration Workshop #2 - Co-located with APAN 46: Management planning, meeting and Deliver training for ambassador (**up to 18 participants**)
v. Ambassador Programs: ambassador (**up to 15**) for promoting/installing/maintaining/ monitoring/training the boxes.

2. Build and Upgrade Together:

i. Access Center Deployment: Providing (up to 20) virtual desktops for high-speed developers
ii. Access Box Deployment: Providing dedicated lightweight desktops (up to 12) for low-speed/ isolated developers
iii. SmartX Box Upgrade: boxes upgrade (**up to 8 sites**) and new installation (**up to 2 sites**)

3. Operate and Automate Together:

i. Establishment of operational mailing-list and operational ticketing systems
ii. Establishment of Initial DataLake for site-to-site Inter-Connection troubleshooting
iii. Establishment of High-availability DataLake (**up to 2 sites**) for joint operation troubleshooting (underlay and overlay playground)

4. Play and Visualize Together:

i. Developers (**up to 22 groups**) from all the community members to propose their experiments or to develop visualizations
ii. Students (**up to 6**) for actively proposing new solutions to be deployed in the playground

5. Investigate and Enrich Together:

i. Enhancing SDX-based deployment: Solutions/designs/plans (**up to 2**) to be deployed
ii. Initial deployment of SOC: Deployment sites (**up to 3 sites**) for initial security collection

Milestones:

<table>
<tr><th>Tasks</th><th>(M1 – M6)</th><th>(M7 – M12)</th><th>(M13 – M18)</th><th>(M19-M22)</th></tr>
<tr><td>Gather and Learn Together</td><td>Workshop report</td><td>Annual meeting report
Ambassador's activity reports</td><td>workshop report
Ambassador's activity reports</td><td>Annual meeting report
Ambassador's activity reports</td></tr>
<tr><td>Build and Upgrade Together</td><td colspan="2">6 access box HW deployment (photos)</td><td colspan="2">6 access box HW deployment (photos)
8 SmartX Box Upgrade (photos)
2 New SmartX Box deployment (photos)
1 DataLake HW Deployment (photos)</td></tr>
<tr><td>Operate and Automate Together</td><td colspan="4" rowspan="2">Monthly playground status report (through email/mailing-list)

2 Annual playground reports</td></tr>
<tr><td>Investigate and Enrich Together</td></tr>
<tr><td>Play and Visualize Together</td><td colspan="2">Annual play reports
(Demos, experiments)</td><td colspan="2">Annual play reports
(Demos, experiments)</td></tr>
</table>

8 Visibility

1. Leverage Github to be the open collaboration platform.

2. A specific Facebook page will be created to promote, share and record all activities for this project. (Videos, Photos, Articles, …) and linked to TEIN*CC and all collaborator sites.

3. Project leaflets, conference/journal publications, invited talks, testimony from each participant site.

4. Publicities in local and international meeting and conferences.

9 Financial contact point

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10 Glossary

Ambassador	Operators or investigators who maintain and monitor the continuous operation and development of OF@TEIN+ playgrounds. They will actively share the experiences and ideas through training/presentation in many different sites (Online/On site).
Developers	Group of researchers who conduct experiments over OF@TEIN+ Playgrounds or making improvement to the playgrounds.
Student Fellows	Local students who help ambassadors and developers activities in each site.
SmartX Box	Commodity server-based hyper-converged resources (compute /storage/networking) to provide experiments (Cloud/SDN/NFV) over OF@TEIN+ Playgrounds.
Access Center	A gateway for accessing OF@TEIN+ Playgrounds from different type of access networks. It is used for developers who have difficulties to access and experiment in the playgrounds.
Access Box (Monitoring Box)	Commodity PC-based box to help the developers for accessing/monitoring the SmartX Box. It is used for out-of-band access/monitoring to the SmartX Box in specific site.
DevOps	Term used to refer culture philosophies, practice, and tools that emphasize the collaboration and communications between developers and operators while automating and accelerating the services delivery.
DataLake	A storage repository that holds a vast amount of raw data in its native format until it is needed. Data lake uses a flat architecture to store data.
SDX	The concept to enhance current IXP (Internet Exchange Point) by enabling Route Server and SDN (software-defined networking) paradigms. It is not only control the route advertisement between

	ASes, but also controls exact forwarding policy on centralized route server.
Security Operation Center (SOC)	Centralized organizations/facilities that deals with security issues on an organizational and technical level. It organizes by highly skilled team who monitor, assessed, and defended all systems for specific organizations/enterprises.