Review Open Call F4Fp-SME - Innovative Experiments - IoTaaS

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Fed4FIRE+ - Virtual Review Meeting

Online

IoT as a Service deployment through gateway virtualization (IoTaaS)

POLYTECH S.A.

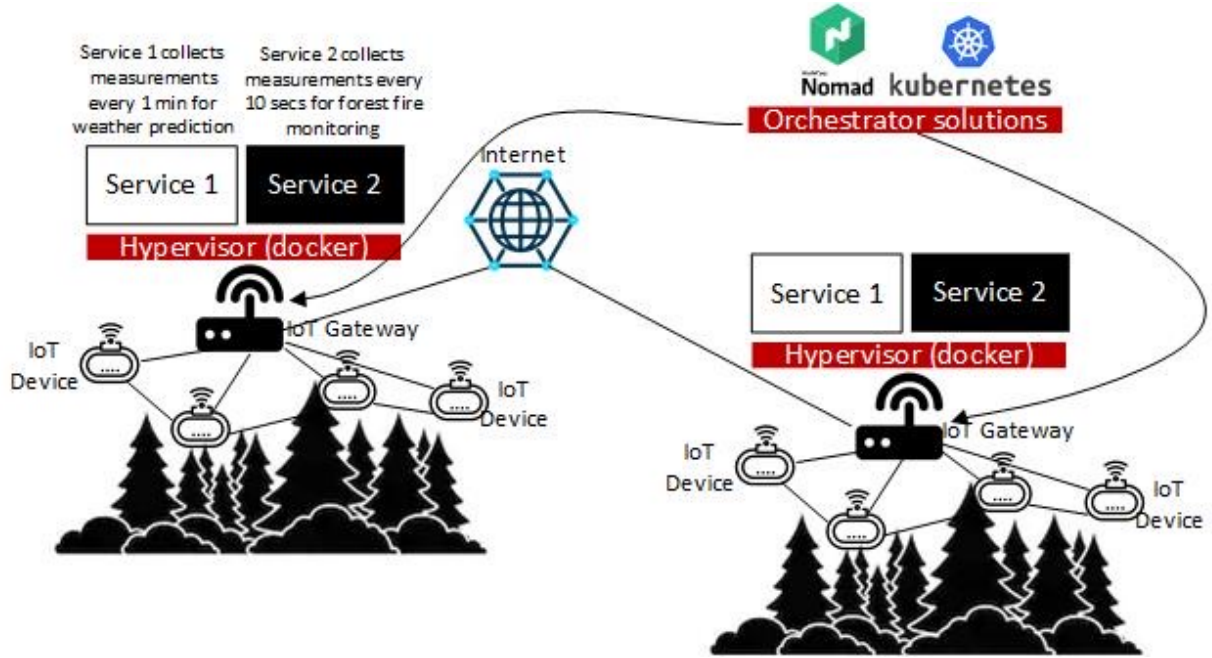
Experiment Description

CONCEPT AND BACKGROUND INFORMATION

- Internet of Things (IoT) is expected to boost its market penetration especially through the deployment of 5G networks
- Smart devices usually use a multi-homed gateway platform in order to interface the Internet through IP connections
- Measurements can be collected by polling each device from the gateway
- Question: can we virtualize the gateway platform efficiently in a 5G based environment?
    - Gateways are usually low-powered resource constrained devices, optimized for their operation of collecting and uploading measurements over the network

Experiment Description

CONCEPT AND BACKGROUND INFORMATION



Model for gateway virtualization examined in the IoTaaS project

IoTaaS Objectives

STAGE 1 OBJECTIVES

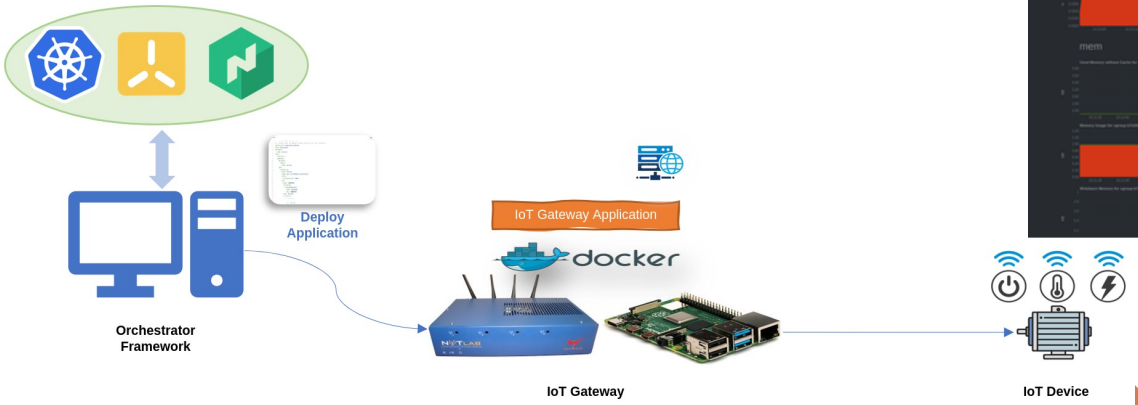
- **To evaluate the execution of virtualized services on top of IoT equipment**
  - Two different target platforms were used for hosting the virtualized services: 1) Generic nodes from the testbed used (NITOS) and 2) Existing gateway devices developed by Polytech, based on the Raspberry Pi 3B+ platform
  - Virtualized services will be executed using the docker virtualization technology
- **To examine different solutions for orchestrating such virtualized IoT environments**
  - The two different platforms have different architectures (x86 for NITOS, ARM for the Polytech solution).
  - Three orchestrators were used and benchmarked for deploying the services on the gateway: 1) Hashicorp Nomad, 2) the Kubernetes platform, and 3) K3s, a lightweight Kubernetes fork
  - Output of the benchmarking process is related to the needed resources, time to deploy the IoT microservices, ease of migrating the solutions to other gateways.
- **To examine the feasibility of slicing and multi-tenancy in IoT equipment**
  - Slicing feasibility of the equipment was examined, when deployed services belong to more than one service provider

Experiment Setup

- Polytech S.A. visited the NITOS premises to install our platform in the testbed
  - The overall setup was supervised by the testbed admins, and was very smooth
- Three testbed images were created with the different orchestrator solutions
- Two more images were created for using the NITOS nodes and our platform as the worker solutions that host the deployed IoT gateway services
- A local docker registry was enabled in the testbed where our IoT application running on the gateway was uploaded
  - With the local registry, time for pulling the image for each orchestrator solution was almost identical

Experiment Setup

- Additional monitoring tools, including the Prometheus monitoring suite and the Netdata tool were deployed for monitoring the resource consumption of each orchestration tool
- All the experiments have been averaged out of 5 different runs



Project Results

RESOURCE LIMITATIONS

- The different orchestrator frameworks have limitations for the hardware that we use to deploy them onto.

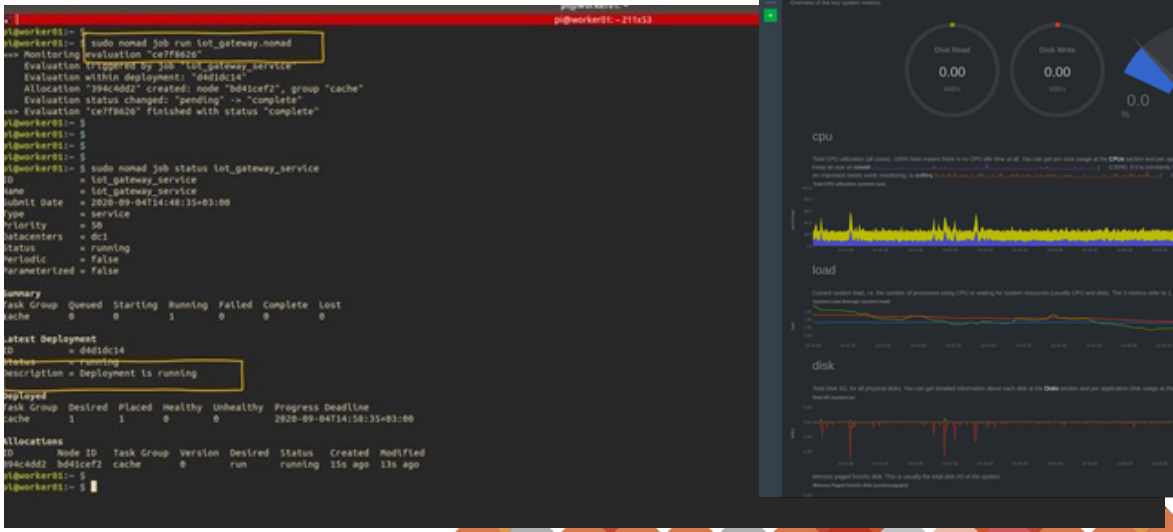
Hardware Requirements						
	CPU (core)		RAM		DISK	
	Master	Worker	Master	Worker	Master	Worker
Nomad	1	0.5	512 MB	256 MB	512 MB	512 MB
K3s	1	0.5	512MB	75 MB	200 MB	200 MB
K8s	1.5	0.5	2 GB	1 GB	2 GB	2 GB

- As our platform is based on the Raspberry Pi Model 3B+ platform (1GB RAM available in total), some of the experiments using K8s cannot be orchestrated

Project Results

EXPERIMENT EXECUTION

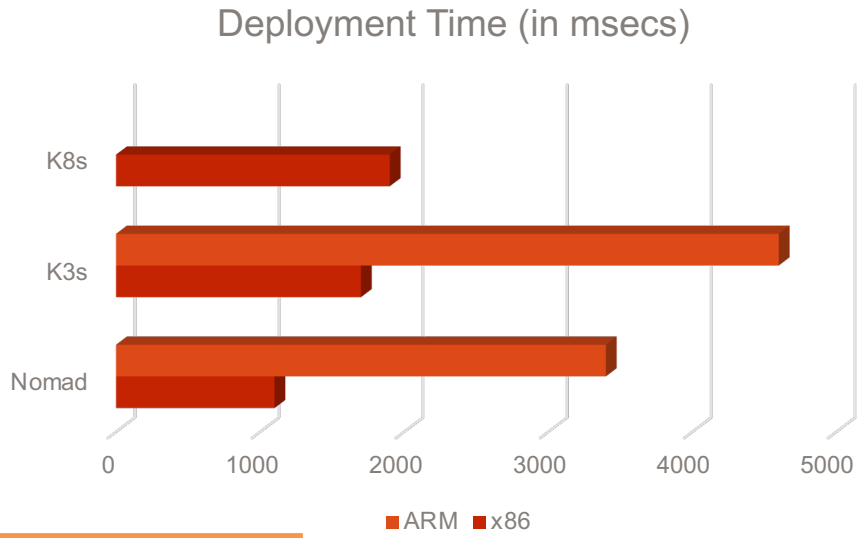
- Six different cases were examined depending on the orchestrator framework and the target gateway platform
- Netdata output was monitored during the experiment execution, to reveal the true host resource utilization



Project Results

EXPERIMENT RESULTS

Experiment parameters: 1) IoT gateway docker container is already present on the worker node, 2) The master node and the worker nodes (x86 NITOS and ARM) are connected back-to-back through a single Ethernet switch, 3) we start the orchestration process from the master node and deploy the docker image on the worker nodes, 4) we measure the time since the beginning of the process i.e. the service descriptor is passed to the respective orchestration service, until the time that the IoT Gateway service is deployed on the worker nodes and is reachable through the network.



	Deployment Time		
IoT Gateway Device	Nomad (sec)	K3s (sec)	K8s (sec)
X86	1.1	1.6	1.8
ARM	3.3	4.6	-

Business Impact

- Polytech S.A. (www.polytech.com.gr) is an SME that active in producing educational material for the vocational training of engineers, medical students, and school students, on the latest technological aspects of their fields.
- The current portfolio of educational services that Polytech offers spans a range of applications, from automotive mechanics to welding, as well as biochemical labs, mathematics and STEAM.
- Several of the laboratories produced by the company involve wireless sensor platforms

Business Impact

- When deployed in a laboratory environment, each student/group of students usually have their own kit
  - One device per kit is required to play the role of the IoT gateway.
- Using dedicated gateways per each kit induces an extra cost of approximately 200 Euros per each kit
- In a real classroom environment, it is mirrored to several thousands of Euros as an extra induced cost, depending on the classroom size.

Business Impact

- Through IoTaaS we investigated the impact of virtualization technologies for IoT gateway
- Potentially can enhance our products towards using less hardware devices, but with integrated virtualization technologies
- This will significantly drop down the overall cost of the platform for large classrooms.
- The experiment has also assisted us in rolling out a new laboratory that deals with Internet of Things, integrating the Nomad framework for managing the deployed applications, which was proved to be the most lightweight option among the ones examined during the IoTaaS experiment

IoTaaS Feedback

FEEDBACK ON THE TESTBED

- The NITOS testbed was used during our experiments
- Two nodes and a Virtual Machine in their Cloud installation for running our local docker registry were used
- 6 images in total were created for the nodes
- Two Polytech S.A. gateways were installed in the testbed for redundancy
    - Only one was eventually used
- The setup for installing the nodes and training for using the testbed was done remotely, with the assistance of the Patron
    - One field visit at the testbed was scheduled in order to install the gateway

IoTaaS Feedback

FEEDBACK ON THE EXPERIMENTATION PROCESS

- The testbed was constantly available for our experiments
- The initial three reservations that we did were mainly for learning the tools and the testbed API
    - Using the testbed portal for creating a slice and reserving resources, OMF tool for creating/loading images
- Although the process for creating and loading images is online available at the testbed Wiki pages, some of the processes can be further simplified
    - Whenever we encountered issues the team was there to assist immediately

IoTaaS Feedback

FEEDBACK ON THE PATRON SUPPORT

- Frequent communication with the Patron was established from the early stages of the experiment
- We sought guidance for using the testbed and installing our hardware
- The testbed admins guided us through the physical topology, and the available tools very quickly
- The testbed was prepared accordingly allowing us to install our equipment very fast, by just plugging it into a networking switch
- Overall, exceptional support!

IoTaaS Feedback

ADDED VALUE

- As a new-comer in Fed4FIRE+ we found the testbed offering very wide that can be used for developing several different products
- The experiments that we conducted were repeated each time with very similar results, which highlights the repeatability that Fed4FIRE+ promotes
- We felt that the overall setup that the testbed provides is highly secure
    - No issues on possible leak of the product data that we uploaded on the server, which was a consideration at the beginning of the experiment


Co-funded by the
European Union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Swiss Confederation

This project has received funding from the European Union's Horizon 2020 research and innovation programme, which is co-funded by the European Commission and the Swiss State Secretariat for Education, Research and Innovation, under grant agreement No 732638.

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