DOSSIER-Cloud

DEVOPS-BASED SOFTWARE ENGINEERING FOR THE CLOUD

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Deliverable D4.2

DevOps Automation Discussions' Minutes and Notes

Document details:

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1.0	05/03/18	Andreas Christoforou	Initial document, structure and content
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4.0	09/04/18	Andreas Andreou	Final review and corrections
5.0	10/04/18	Luciano Baresi, Mike Papazoglou	Approved final version

Contents

1. Introduction

1.1 Purpose

This document quotes minutes and notes from various discussion meetings that have taken place in the context of site visits, workshops and summer schools. During these meetings researchers from the University of Tilburg (UvT), Politecnico di Milano (POLIMI) and the Cyprus University of Technology (CUT) met, discussed and exchanged research ideas.

This deliverable is part of Workpackage-4 (WP4) that describes the actions to enable a successful transfer of knowledge from the leading institutions to CUT and for luxuriating its knowledge base on technical issues of automatic synthesis of Cloud services to build larger applications and composition of Cloud services residing at multiple distributed environments.

1.2 Definitions, Acronyms, and Abbreviations

CUT: Cyprus University of Technology

UvT: University of Tilburg

POLIMI: Politecnico di Milano

1.3 Overview

The rest of the document is structured as follows: In Section 2 minutes and notes from the second series of site visits at the Politecnico di Milano are quoted, while Section 3 presents minutes and notes from the second series of site visits series at University of Tilburg. Section 4 presents the minutes and notes from the workshop that took place at CUT and finally, Section 5 concludes the document.

2. POLIMI Site Visits

2.1 First Site Visit (August 28-30, 2017)

During the first site visit of the third series of site visits, members from the CUT group attended several presentations given by the POLIMI group, as well participated in discussions related to the topic of WP4. In particular, the general subject of these presentations and discussions was dealing with research challenges in microservices, containerization of cloud applications and the corresponding metrics, and DevOps strategies with social software engineering. The notes/minutes are quoted below:

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	08/28/2017	Time:	14:00-16:00
Facilitator:		Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Discussion on recommendations for microservices synthesis

2. Attendees			
Name	Department/Division	E-mail	Phone
Panayiotis Christodoulou, PhD Student	CUT / Cyprus	panayiotis.christodoulou@cut.ac.cy	
Giovanni Quattrocchi, PhD Student	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Prof. Luciano Baresi	luciano.baresi@polimi.it	luciano.baresi@polimi.it	

3. Discussion notes		
Topic and targets	Introducer	Time
Investigate the development of methods, algorithms and tools for microservices synthesis **Prerequisite activities:** ▪ Analysis and deep understanding of adaptive and optimized service selection and composition targeting automatic synthesis ▪ Synthesis of microservices hosted on different distributed environments ▪ Automatically or semi-automatically ▪ Requirements definition ▪ Definition of microservices characteristics following the same standard description as the one used for requirements definition. ▪ Recommendation engine characteristics	Panayiotis Christodoulou, PhD Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	08/29/2017	Time:	09:00-11:00
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Talk on recommendation engine for microservices suitability

2. Attendees			
Name	Department/Division	E-mail	Phone
Panayiotis Christodoulou, PhD Student	CUT / Cyprus	panayiotis.christodoulou@cut.ac.cy	
Giovanni Quattrocchi, PhD Student	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Prof. Luciano Baresi	luciano.baresi@polimi.it	luciano.baresi@polimi.it	
Martin Garriga, Post-doctoral Student	POLIMI / Italy	martin.garriga@polimi.it	

3. Discussion notes		
Topic and targets	Introducer	Time
Recommendation Engine selection Which approach is more suitable? Recurent Neural Network Bayesian Inference Statistical Methods Other …. What about real time recommendations → microservices synthesis What issues should be considered targeting automatic microservices synthesis?	Panayiotis Christodoulou, PhD Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	08/29/2017	Time:	11:30-13:30
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Discussion on research challenges related to recommendations for microservices synthesis

2. Attendees

Name	Department/Division	E-mail	Phone
Panayiotis Christodoulou, PhD Student	CUT / Cyprus	panayiotis.christodoulou@cut.ac.cy	
Giovanni Quattrocchi, PhD Student	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Martin Garriga, Post-doctoral Student	POLIMI / Italy	martin.garriga@polimi.it	

3. Discussion notes

Topic and targets	Introducer	Time

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	08/30/2017	Time:	09:00-11:00
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description

Brainstorming and discussion on a novel recommendation engine for microservices synthesis

2. Attendees

Name	Department/Division	E-mail	Phone
Panayiotis Christodoulou, PhD Student	CUT / Cyprus	panayiotis.christodoulou@cut.ac.cy	
Giovanni Quattrocchi, PhD Student	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Martin Garriga, Post-doctoral Student	POLIMI / Italy	martin.garriga@polimi.it	
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	

3. Discussion notes

Topic and targets	Introducer	Time
Define steps towards the development of a novel recommendation engine for microservices synthesis ○ POLIMI group will provide a draft document regarding microservices description, characteristics and profiling methods ▪ BNF, TOSCA etc. ○ CUT group will investigate the adoption of the same description methods for requirements ○ CUT group will investigate and prepare a list of possible approaches and algorithms to develop an automatic synthesis	Panayiotis Christodoulou, PhD Student	

recommendation engine ▪ Specifications and Ontologies ▪ ComProFITS ▪ Neural Nets ▪ Bayesian Inference ○ Approach selection through a joint skype call ○ Review and follow up on the next joint meeting		

2.2 Second Site Visit (September 7-13, 2017)

Members from the CUT group participated in the second site visit at POLIMI. During this visit members from the POLIMI group presented their work that is related to software development and deployment for distributed applications. Also, various joint discussions with the participation of members from both groups took place, where the possibility of new research work was investigated.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	09/08/2017	Time:	09:30-11:00
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Social Dept

2. Attendees			
Name	Department/Division	E-mail	Phone
Damian Andrew Tamburri, Post-doctoral Student	POLIMI / Italy	damianandrew.tamburri@polimi.it	

Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@cs.ucy.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	
Maria Christodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
This session concluded site visit with planning of next steps, followed by team coordination activities: • Social debt Next important steps: perform fuzzy analysis of concepts, to better understand each concept and help decide the metric to adopt to initialize each corresponding activation level, and to merge similar concepts together, to reduce the size of the model. • Community smells Next step is to run more project analyses in order to generate further datasets and, in addition, to determine which algorithms to apply.	Adonis Podinas, MSc Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	09/13/2017	Time:	11:30-13:00
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Project organization and future planning

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Danilo Ardagna	POLIMI / Italy	danilo.ardagna@polimi.it	
Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@cs.ucy.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	
Maria Christodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
Research on Edge Computing • POLIMI members will provide relevant material • CUT members will study material provided by POLIMI members • CUT members will suggest possible collaboration topics on Edge Computing • New joint discussions will take place during upcoming Workshop • **Research on Social Dept** • Stefanos with Constantinos will provide a schedule plan for next research steps in cooperation with Damian	Adonis Podinas, MSc Student	

3. UvT Site Visits

3.1 Second Site Visit UvT (July 2-3,2017)

Researchers from the CUT group participated in the first site visit, of the second series visits, in UvT. During this visit a number of research collaboration activities took place between members from UvT, CUT and VU (Vrije Universiteit Amsterdam). The meetings covered a wide range of aspects and research topics on smart data systems and microservices architecture.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	07/02/2017	Time:	09:00-11:00
Facilitator:	UvT	Location:	Amsterdam, The Netherlands

1. Subject / Short Description
Planning on research perspectives in the areas of distributed software engineering and software services

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Prof. Ivano Malavolta	VU / The Nederlands	i.malavolta@vu.nl	

3. Discussion notes		
Topic and targets	Introducer	Time
• Review of areas from last meeting. • Green lab. • Personality. • Mobile applications and automatic construction of mobapps through services. • Software reliability. • Wrap up for tomorrow's meeting.		

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	07/02/2017	Time:	11:00-13:00
Facilitator:	UvT	Location:	Amsterdam, The Netherlands

1. Subject / Short Description
Preparation for meeting with Department of Computer Science, Faculty of Science, Vrije University Amsterdam, suggestions for future research actions and collaboration for future EU funding

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Ivano Malavolta	VU / The Nederlands	i.malavolta@vu.nl	
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
Green lab • Power meters to measure performance • Energy efficiency of mobile apps • EaaS • Measure software practices and quality levels then experiments with industry for refactoring • Measure impact • Architectural tactics, design decisions and implementation trade-offs. For example, cyber foraging, detection of problems and self-adaptation for energy consumption. • Inject best practices programmatically	Constantinos Stylianou, PhD	

Possible collaboration: dynamic reconfiguration

Personality

- Feminine and masculine decision-making traits
- Architecture decision-making personality traits
- Educational game for teachers aimed at better decision making

Possible collaboration: organizational/staffing decision making and personality traits

Cloud

Domain model for IoT/self-adaptation

Notion of relevance is vague

Context changes with the emergence of new devices

Possible collaboration: FCMs as a tool for forecasting

Projects

Urban Europe project for metrics/KPIs regarding how to measure for decision making

Online survey for sustainable reasoning

Possible collaboration: conduct investigation on sustainability and FCM integration

Next steps

Share papers on FCMs and microservices

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	07/03/2017	Time:	13:00-14:00
Facilitator:	UvT	Location:	Room P.423 Sciences building, 4th floor De Boelelaan 1105, 1081 HV Amsterdam, Netherlands

1. Subject / Short Description
Summary closing – Discussion on future research collaboration

2. Attendees

Name	Department/Division	E-mail	Phone
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Prof. Patricia Lago	VU / The Nederlands	p.lago@vu.nl	
Prof. Ivano Malavolta	VU / The Nederlands	i.malavolta@vu.nl	

3. Discussion notes

Topic and targets	Introducer	Time
• Ivano presented some of their papers with emphasis on mobile applications and code migration, and distributed (Cloud applications) • CUT's team presented the concept of DOSSIER-Cloud project and the main pillars of research. • CUT: Explained how automation will be performed through AI/CI techniques. Also explained about the vision for automatic software services synthesis and recommender	Prof. Andreas Andreou	

systems.
• Topics of mutual interest
  ○ Software reliability
  ○ Cloud and distributed services or systems (properties, factors and parameters)
  ○ Optimization of code migration for mobile applications and web services
  ○ Software architectures (tactics) for distributes services and applications for optimizing properties like performance and security.
• CUT presented the theory and application of FCM and suggested to use them in problems addressed by VU-A
• CUT presented also the principles behind the frameworks for automatically assessing the suitability of software components for promoting reuse.
• Agreed that there are synergies and complementarities.
• There was strong interest to exploit these synergies and investigate how the two teams may collaborate in the future.
  ○ Visits either in the context of DOSSIER or Erasmus agreements
  ○ Start collaborating and discussing through teleconferencing
• The two teams will exchange relevant papers. After studying them a skype call will be arranged to discuss future steps.		

3.2 Third Site Visit UvT (July 3-8, 2017)

Researcher from the CUT group participated in the third site visit, of the third series visits, in UvT. During this visit researchers from CUT, UvT and Philips Lighting discussed the possibility of collaboration on various applied research areas in the context of Dossier-Cloud project.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (DD/ MM /YYYY)	03/07/2017	Time:	09:30-16:00

Facilitator:	UvT	Location:	Jheronimus Academy of Data Science Sint Janssingel 92 5211 DA 's-Hertogenbosch The Netherlands

1. Subject / Short Description
Collaboration with Philips Lighting Research and Tilburg University: exploration of research subjects in the area of ''Data pipelines'', discussions, brainstorming, talking of research challenges.

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Mike Papazoglou	UvT / The Netherlands	mikep@uvt.nl	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Prof. Willem-Jan van den Heuvel	UvT / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	

3. Discussion notes		
Topic and targets	Introducer	Time
• Realtime Data Processing at Facebook https://research.fb.com/wp-content/uploads/2016/11/realtime_data_processing_at_facebook.pdf? • Evolution of the Netflix Data Pipeline (Recommended) Blog: https://medium.com/netflix-techblog/evolution-of-the-netflix-data-pipeline-da246ca36905 Video: https://www.youtube.com/watch?v=6ocfbpxBobQ Video: https://www.youtube.com/watch?v=hTfIAWhd3qI FYI. Collaborative Filtering, Samza for routing, S3 () and EMR (Elastic Map Reduce, https://aws.amazon.com/emr/)	Maria Papachristodoulou, MSc Student	

• The LinkedIn Android Data Pipeline https://engineering.linkedin.com/blog/2016/03/the-linkedin-android-data-pipeline		

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (DD/ MM /YYYY)	04/07/2017	Time:	09:30-16:00
Facilitator:	UvT	Location:	Jheronimus Academy of Data Science Sint Janssingel 92 5211 DA 's-Hertogenbosch The Netherlands

1. Subject / Short Description
Collaboration with Philips lighting research and Tilburg University: exploration of research subjects in the area of ''Data pipelines'', discussions, brainstorming, talking of research challenges.

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Mike Papazoglou	UvT / The Netherlands	mikep@uvt.nl	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Prof. Willem-Jan van den Heuvel	UvT / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	

3. Discussion notes		
Topic and targets	Introducer	Time
Netflix : • internet television network • 81 million subscribers • 190+ countries • 125 million hours of TV shows and movies per day **Data pipeline is the plumbing that connects all data producers and consumers together** • Centralize the collection of the data • Support it so customers can get the SLAs and SLOs that they are looking for **Questions** • what is an SLO • what is a/b test **Uses of data Pipeline** • Business data(viewing information, a/b test) • System data through (Log data)- data going through the system **Keystone Pipeline v2** **Event producers:** Produce events, they decide what is needs to be admitted in the data pipeline **Data Pipeline (Main Topic):** All the data goes through the data pipeline before it ends up to somewhere where it can be consumed by a user **SLAs (Service Level Agreement):** • Drop event rather than cause an error (so the end user experience continues) • …. Kafka producers: embedded in java application, allow events to be sent	Maria Papachristodoulou , MSc Student	

HTTP client: allows non java applications to just send an HTTP post of message and it ends up in the fronting tier

Internal routing service: picks up the messages from fronting tier and directs the where they need to go. Handles the pushing of the data out to the consumers that need it

Case 1: go to S3
Case 2: go to Elastic Search
Case 3: go to Kafka
Case 4: All three

Management API: Set of self-management tools (ex. New data stream, new routing set up)

Configuration: What streams are where and how it all hangs together

That wasn't able to keep up with the availability and scaling needed, so moved to Kafka based solution

Fronting Tier:

- Receives all ingested events
- 8 Kafka Clusters (Single test cluster) (Over 3000 servers)
- In depended failure domains
- Separate producers from consumers

D2excels, amazon ec2 system?

Replication factor of 2- works because of 15 minuet SLA, when data arrives they can get them into the system back end very quickly (small replicator factor). With this small replication factor all servers run in full network utilization all the time

Retention cycle: 8-24 h

Producers and consumers connect to different Kafka clusters. Works like a buffer, they are dealing with one problem at a time.

Kafka for producer: ingest the messages

Kafka for consumer: process the message

Can scale producers and consumers separately. No need of the same number of shards within paths, or same number of partitions within the stream

Control and separate up consumer workloads		

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (DD/ MM /YYYY)	05/07/2017	Time:	09:30-16:00
Facilitator:	UvT	Location:	Jheronimus Academy of Data Science Sint Janssingel 92 5211 DA 's-Hertogenbosch The Netherlands

1. Subject / Short Description
Collaboration with Philips Lighting Research and Tilburg University: exploration of research subjects in the area of ''Data pipelines'', discussions, brainstorming, talking of research challenges.

2. Attendees			
Name	Department/Division	E-mail	Phone
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Prof. Willem-Jan van den Heuvel	UvT / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	

3. Discussion notes		
Topic and targets	Introducer	Time
Netflix Technology Blog :Evolution of the Netflix Data Pipeline	Maria Papachristodoulou,	

In this article, the author writes about Netflix's data pipeline evolution. Netflix in overall is an internet television network and its data driven, has to handle huge number of events and amount of data every day. There are several types of streams go through the pipeline every day such as video viewing activities, error logs and performance events. In the beginning the purpose of the pipeline was to aggregate and upload events to Hadoop/Hive for batch processing. The processing took place daily or hourly. The architecture of v1.0 Chuckwa Pipeline was rather simple. In front, there were the event producers and where directed to S3 in Hadoop format so those files could be batch processed later in Hive. After couple of years elastic search and Kafka emerged, also the demand for real time processing was high. The V1.5 Chuckwa pipeline with real-time branch arises. This version of the pipeline has a real-time branch, Kafka was in the front line of the branch, the centrepiece of was a router which was responsible to direct the data to from Kafka to the various available sinks like elastic search or the secondary Kafka. Although the new architecture there were few issues. When new code was pushed, sometimes the user could get stuck into a bad state, also there was operational overhead of managing thousands of jobs in dozens of clusters. These matters and also other reasons like replication which would improve the durability, motivated the reinvention of V2 Keystone Pipeline (Kafka fronted). Keystone Pipeline has three major components which are: Data Ingestion, Data Buffering and Data Routing. There are two ways to emit data into the pipeline, through the use of Java Library/ direct to Kafka, or through HTTP client which enables non-java applications to send HTTP Post which is going directly to the fronting tier. The data buffering part, helps absorb temporary outrages of the sinks also Kafka works like replicated persistent message queue. The third and last part of the architecture is the routing which is responsible for picking up messages from fronting tier, and directs them where they need to go. Handles the pushing of the data out to the consumers that need it. There is development still going on regarding QoS, scalability, availability, operability and self-service.	MSc Student	

The future work is regarding: • How are they going to run Kafka on Cloud at scale? • How are they going to implement routing service using Samza? • How are they going to manage and deploy Docker containers for routing service?		

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (DD/ MM /YYYY)	06/07/2017	Time:	09:30-16:00
Facilitator:	UvT	Location:	Jheronimus Academy of Data Science Sint Janssingel 92 5211 DA 's-Hertogenbosch The Netherlands, The Netherlands

1. Subject / Short Description
Collaboration with Philips Lighting Research and Tilburg University: exploration of research subjects in the area of ''Data pipelines'', discussions, brainstorming, talking of research challenges.

2. Attendees			
Name	Department/Division	E-mail	Phone
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Prof. Willem-Jan van den Heuvel	UvT / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	

3. Discussion notes		
Topic and targets	Introducer	Time

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	07/07/2017	Time:	09:30-16:00
Facilitator:	UvT	Location:	Jheronimus Academy of Data Science Sint Janssingel 92 5211 DA 's-Hertogenbosch The Netherlands

1. Subject / Short Description
Collaboration with Philips lighting research and Tilburg University: exploration of research subjects in the area of ''Data pipelines'', discussions, brainstorming, talking of research challenges.

2. Attendees			
Name	Department/Division	E-mail	Phone
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Prof. Willem-Jan van den Heuvel	UvT / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	

3. Discussion notes		
Topic and targets	Introducer	Time
Urban planning and building smart cities based on the Internet of	Maria	

Things using Big Data analytics **Notes** Proposal: Authors propose a combined IoT-based system for smart city development and urban planning using Big Data analytics, a complete system consisting of various types of sensor deployment. Sensors: • smart home sensors • vehicular networking • weather and water sensors • smart parking sensors • surveillance objects. • Four tier Architecture: 1) Bottom tier-1, which is responsible for IoT sources and data generation and collection 2) Inter- mediate tier-1, which is responsible for all types of communication between, for instance, sensors, relays, base stations, and the Internet 3) Intermediate tier 2, which is responsible for data management and processing using a Hadoop framework 4) Top tier, which is responsible for application and usage of the data analysis and the results generated. In this paper, authors propel the concept of the smart home to the smart city with the idea of urban planning and development based on Big Data analytics. In the paper, we propose a complete architecture to develop the smart city and conduct urban planning using IoT-based Big Data analytics. The 4-tier architecture is proposed, which has the capability to analyse the large amount of IoT datasets generated from various sources of the smart system in the city, such as smart homes, smart car parking, vehicular traffic, and others. In addition, the complete system implementation model guides various municipalities to implement the system. Moreover, the analysis is performed on the IoT datasets to make smart city decisions using the proposed system. Finally, the system is tested and evaluated with respect to efficiency	Papachristodoulou, MSc Student	

measures in terms of throughput and processing time.

Queries:

- How to tackle uncertainty induced due to real-time and offline dynamics and ensure the quality of information.
- How to make existing objects smarter. Alternatively, how to design new objects to be smarter based on user choice.
- How to enable objects to react accordingly with respect to context.
- How to minimize the cost of data collection that is being generated by some devices.
- How to obtain insight into the data if the data are collected and going to the processing stage in real time.

Implementation:

- The system implementation consists of various steps
- data generation
- move to collection
- aggregation
- filtration
- classification
- pre-processing
- computing
- decision making.

The proposed system is implemented using:

- Hadoop with Spark
- voltDB
- Storm or S4 for real time processing of the IoT data to generate results to establish the smart city

For urban planning or city future development, the offline historical data are analysed with Hadoop using MapReduce programming.

Generated Datasets:

IoT datasets generated by smart homes, smart parking weather, pollution, and vehicle data sets are used for analysis and evaluation.

Current System

This is not an existing system, its demonstration showed that is more efficient and scalable than the existing ones.

They measure the efficiency in terms of throughput and processing time.

Fact:

In 2008, CISCO reported that the number of things connected to the Internet surpassed the number of people living on earth whereas in 2020, it will reach the limit of 50 billion, resulting in the enrichment of the digital world.

IoT

IoT domains:

- health- care
- automation
- transportation
- emergency responses to manmade
- natural disasters

Under which these circumstances are difficult to make decisions.

IoT empowers object to:

- hear
- see
- listen
- communicate

All this at the same time.

Concept:

Smart homes where different electronic appliances are interconnected with each other and achieve high-quality two-way interactive multimedia services. In such a system where a large number of devices are communicating with each other, a massive volume of data (called Big Data) is generated. To enrich smart home technology, the better analytics of Big Data could play a vital role in the advancement of Information and Communications Technologies (ICTs)

Control sensors remotely:

A large number of the devices involved sense the surrounding activities and transmit a massive amount of data to the remote station where it can be processed, analysed, and predict or give a response to the user for his/her convenience based on the received

data. **This Research:** Focused on individual homes. Similarly, the idea of the smart home is extending to the Smart Community where the Home Domain, Community Domain, and Service Domain are integrated to benefit people. Challenges: However, this technology is lacking in various factors, such as how to connect vehicles, roadside units, GPS, and others to the same infrastructure, i.e., the web A possible Case Study recommended by Indika Kumara: **Notes / Improvements** • Use of Fog Computing • GDPR European data Standards? •		

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	07/08/2017	Time:	09:30-16:00
Facilitator:	UvT	Location:	Jheronimus Academy of Data Science Sint Janssingel 92 5211 DA 's-Hertogenbosch The Netherlands

1. Subject / Short Description
Summarization of the work performed and wrap-up – Planning of next actions

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Mike Papazoglou	UvT / The Netherlands	mikep@uvt.nl	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Prof. Willem-Jan van den Heuvel	UvT / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	

3. Discussion notes		
Topic and targets	Introducer	Time
• **Urban planning and building smart cities based on the Internet of Things using Big Data analytics** Challenges: However, this technology is lacking in various factors, such as how to connect vehicles, roadside units, GPS, and others to the same infrastructure, i.e., the web A possible Case Study recommended by Indika Kumara: <u>Notes / Improvements</u> • Use of Fog Computing • GDPR European data Standards? • **Netflix Technology Blog** :Evolution of the Netflix Data Pipeline The future work is regarding: • How are they going to run Kafka on Cloud at scale? • How are they going to implement routing service using Samza? How are they going to manage and deploy Docker	Maria Papachristodoulou, MSc Student	

containers for routing service?		

4. POLIMI Workshop – Italy (Sept 14-15, 2017)

Representatives from all project partners participated in the second workshop organized at the CUT premises in Limassol. During this 2-day workshop members from POLIMI and UvT delivered lectures and presentations to members of the CUT group. Also, a project management meeting was conducted in which members from all partners discussed the progress of the project.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	09/14/2017	Time:	11:00-13:30
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Discussion on research challenges related to data pipelines: framework monitoring and management

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Prof. Willem-Jan van den Heuvel	Tilburg / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	
Giovanni Quattrocchi, PhD	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	

Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@edu.cut.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	

3. Discussion notes

Topic and targets	Introducer	Time
Big Data Chalenges **Data Characteristics** ○ Data integration complexity ○ Architecting big data system ○ Data ownership and other political issues ○ Data security, privacy, governance ○ Real time data ○ Data quality ○ Lack of metadata for big data **Data Process** ○ Acquisition and warehousing ○ Mining and cleaning ○ Agreegationa and integration ○ Modelling ○ Interpretation ○ Real time data **Data Management** ○ Data integration complexity ○ Architecting big data system ○ Data ownership and other political issues ○ Data security, privacy, governance ○ Data quality ○ Lack of metadata for big data	Maria Papachristodoulou, MSc Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	09/14/2017	Time:	15:00-16:00
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Research Collaboration/Project management meeting

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Martin Garriga, PhD	POLIMI / Italy	martin.garriga@polimi.it	
Prof. Willem-Jan van den Heuvel	Tilburg / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	
Giovanni Quattrocchi , PhD	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Danilo Ardaga, PhD	POLIMI / Italy	danilo.ardaga@polimi.it	
Athanasia Evangelinou, PhD	POLIMI / Italy	athanasia.evangelinou@polimi.it	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@edu.cut.ac.cy	

Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
Define Agenda for next events? Project Management meeting - notes *(Thursday afternoon or Friday 11-1 , 2pm-afternoon Andreas participate) *Final dates : 30-31/10 workshop @ Cyprus (Mike, Willem Yian, Luciano, Damian?) *Summer School : Possible dates 27/9-4/10 (2 talks per day) Suggested days 2-6/10 Luciano 5-6/10 Martin 3-6/10 ? Cover 1 week (how many persons?) Research : Discussion with Martin and Luciano Set deadlines Who? When? Where?	Andreas Christoforou, PhD Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	09/15/2017	Time:	11:30-13:30
Facilitator:	POLIMI	Location:	POLIMI, III floor, building 22, via Golgi, 42, Milan

1. Subject / Short Description
Summary – Planning of next research steps

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Martin Garriga, PhD	POLIMI / Italy	martin.garriga@polimi.it	
Prof. Willem-Jan van den Heuvel	Tilburg / The Netherlands	w.j.a.m.vdnheuvel@tilburguniversity.edu	
Giovanni Quattrocchi, PhD	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@edu.cut.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
• Extend ICSOC paper o Attract as many industrial experts we can o Utilize Social Networks / Students o Luciano will prepare a list of microservices experts o New research questions to be defined o Employee MOO algorithms to search for specific “answers” ???	Andreas Christoforou, PhD Student	

○ Prepare two types of questionnaires ▪ Real world cases ▪ Experts feedback • Resource management on cloud ○ Follow up Prof. Danilo's paper ○ Follow up Prof. Luciano's paper ○ Define steps : ▪ Select cloud environment (Azure) ▪ Check if there are libraries with MOO algorithms in python ▪		

5. CUT Workshop – Cyprus (Oct 30-31, 2017)

Representatives from all project partners participated in the second workshop organized at the CUT premises in Limassol. In this 2-day workshop members from POLIMI and UvT delivered lectures and presentations based on the topics covered during the second site visits series.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	10/30/2017	Time:	12:15-13:00
Facilitator:	CUT	Location:	EE-CEID, 39, Saripolou & Socratous, Limassol

1. Subject / Short Description
Project Management Meeting

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Giovanni Quattrocchi, PhD	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time

***Make sure that all partners have collected and provided all material for Deliverables to responsible persons.
 	
Next site visits:
• Visits to POLIMI
  ○ One group in November
  ○ One group in December
• Visit to Tilburg
  ○ One group in December
• Finalise Topics and agendas
	Andreas Christoforou, PhD Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	10/30/2017	Time:	15:00-17:00
Facilitator:	CUT	Location:	EE-CEID, 39, Saripolou & Socratous, Limassol

1. Subject / Short Description
Research follow up meeting

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Giovanni Quattrocchi, PhD	POLIMI / Italy	giovanni.quattrocchi@polimi.it	
Michael Pingos	CUT / Cyprus	mf.pingos@edu.cut.ac.cy	
Nicolas Charalambous	CUT / Cyprus	nx.charalampous@edu.cut.ac.cy	
Spyros Loizou	CUT / Cyprus	Sp.loizou@edu.cut .ac.cy	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@edu.cut.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
Prof. Danillo follow up ○ Space4Cloud ??? ○ New ideas utilizing Machine learning algorithms ○ Provide material ▪ Experiments ▪ Parameters ▪ Papers	Andreas Christoforou, PhD Student	

Prof. Luciano follow up ○ Nikolas should become familiar with EcoWare ○ Control theory alternative approach ○ ???		

6. Summer School – Cyprus (Oct 04-06, 2017)

The 2nd mini-school (Part A') on Cloud Computing, Software Services and Smart Data Processing, in the context of the Dossier-Cloud project, was organized in October and included a project meeting and lectures from senior researchers from POLIMI. In the project meeting members from CUT and POLIMI, and from UvT through teleconferencing means, discussed about the project progress and organized next steps. Lectures by POLIMI researchers were attended by undergraduate and postgraduate students, as well as academic staff from CUT.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	10/05/2017	Time:	09:00-10:00
Facilitator:	CUT	Location:	EE-CEID, 39, Saripolou & Socratous, Limassol

1. Subject / Short Description
Project Management Meeting

2. Attendees			
Name	Department/Division	E-mail	Phone

Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
Next Steps: o Organise Workshop in Cyprus ▪ Possible dates in period between 20/2/2018 – 15/3/2018 ▪ Send emails to Prof. Luciano, Prof Papazoglou and Prof Willem-Jan ▪ Topics related to WP4 • Fast and fine-grained resource provisioning for modern software system (Giovanni Quattrocchi) • Microservices are not just tiny services (Luciano Baresi) • Smart Connected Digital Factories: Unleashing the Power of Industry 4.0 and the Industrial Internet (Mike Papazoglou) • The Manufacturing Blueprint Environment: Bringing Intelligence into Manufacturing (Mike Papazoglou)	Andreas Christoforou, PhD Student	

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	10/05/2017	Time:	10:00-15:00
Facilitator:	CUT	Location:	EE-CEID, 39, Saripolou & Socratous, Limassol

1. Subject / Short Description
Research follow up meetings

2. Attendees			
Name	Department/Division	E-mail	Phone
Prof. Luciano Baresi	POLIMI / Italy	luciano.baresi@polimi.it	
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Martin Garriga, PhD	POLIMI / Italy	martin.garriga@polimi.it	
Damian Andrew Tamburri, Post-Doctoral Student	POLIMI / Italy	damian.andrew.tamburri@polimi.it	
Michael Pingos	CUT / Cyprus	mf.pingos@edu.cut.ac.cy	
Nicolas Charalambous	CUT / Cyprus	nx.charalampous@edu.cut.ac.cy	
Spyros Loizou	CUT / Cyprus	sp.loizou@edu.cut .ac.cy	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	
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Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@edu.cut.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
*Meeting for research • Resource Management - Control theory->ML (Chatzis) which model will be replaced who is going to be responsible? Set milestones	Andreas Christoforou, PhD Student	

• ICSOC paper extension Questionnaire for Industry cases Questionnaire for experts - calibrate our model Finalize questionnaires until next weekend ▪ -Send questionnaires during next week 9/10 ▪ -reminder at 16/10 ▪ -wait until 25/10 ▪ -Deliver preliminary results during workshop -30-31/10 ▪ -Try to spread questionnaires during icsoc ▪ -meanwhile ***Get Presentations from Martin Luciano Damian		

7. Summer School – Cyprus (Oct 25-27, 2017)

The second part of the 2nd mini-school on Cloud Computing, Software Services and Smart Data Processing, in the context of the Dossier-Cloud project, was organized at the end of October. Lectures were given by UvT researchers which were attended by undergraduate and postgraduate students, as well as academic staff from CUT.

Workpackage:	WP4 – Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration		
Date: (MM/DD/YYYY)	10/27/2017	Time:	10:00-13:00
Facilitator:	CUT	Location:	EE-CEID, 39, Saripolou & Socratous, Limassol

1. Subject / Short Description
Discussion, future work and follow up

2. Attendees			
Name	Department/Division	E-mail	Phone
Indika Preyantha, PhD	UvT / The Netherlands	pkumarawd@yahoo.com	
Prof. Andreas Andreou	CUT / Cyprus	andreas.andreou@cut.ac.cy	
Michael Pingos, MSc Student	CUT / Cyprus	mf.pingos@edu.cut.ac.cy	
Nicolas Charalambous, MSc Student	CUT / Cyprus	nx.charalampous@edu.cut.ac.cy	
Spyros Loizou, MSc Student	CUT / Cyprus	sp.loizou@edu.cut .ac.cy	
Constantinos Stylianou, PhD	CUT / Cyprus	cstylianou@cs.ucy.ac.cy	
Andreas Christoforou, PhD Student	CUT / Cyprus	ax.christoforou@edu.cut.ac.cy	
Maria Papachristodoulou, MSc Student	CUT / Cyprus	mk.papachristodoulou@edu.cut.ac.cy	
Stefanos Manoli, MSc Student	CUT / Cyprus	sp.manoli@edu.cut.ac.cy	
Adonis Podinas, MSc Student	CUT / Cyprus	ak.podinas@edu.cut.ac.cy	

3. Discussion notes		
Topic and targets	Introducer	Time
Next Site visit to UvT Final Dates: 3/12-9/12 Participants from CUT group: Michalis, Spiros, Christoforos and Panayiotis Study the research work entitled "The Manufacturing Blueprint	Michael Pingos, MSc Student	

Environment: Bringing Intelligence into Manufacturing” Indika will provide Blueprint documents and presentations Blueprint Models and repository structure **Crossynm project** Get sample data -> A Concept memorandum and a non-disclosure agreement should be signed by all partners.		

8. Conclusions

In the context of Workpakage-4, a number of actions and activities were organized and performed aiming to transfer scientific knowledge to CUT members in the area of Automatic monitoring of service delivery, Cloud resource management and decision support and/or automatic re-configuration.

A series of visits were performed for WP4 starting from the Netherlands and and continuing with Italy. CUT members attended various lectures given by UvT and POLIMI that covered a wide range of aspects and research topics on cloud distributed systems, such as data science and intelligence sharing, big data and analytics, microservices, resource management on the cloud with the corresponding metrics and monitoring tools, and DevOps strategies with social software engineering. The site visits were concluded with a 2-day workshop organized at the premises of CUT which concluded the site activities of Task 4.1. The workshop included a project management meeting, lectures delivered by senior researches and faculty from POLIMI and UvT.

Task 4.1 was completed with a 6-day school organized in Cyprus, splitted in two parts, which was involved with tipics such as Microservices and Serverless architecture, cloud and big data architectural styles, architecting DevOps and introduction to smart manufacturing and Industry 4.0.

During Workpackage 4 activities, various project management and discussion meetings were organized. This document quoted the most significant minutes and notes from all those meetings and the relevant discussions on the project’s progress and future steps, as well as possible future research collaborations and submission of joint proposals for funding under EU or national calls.