PhD Subject / CIFRE contract

SLA-aware MicroServices Architecture programming on fault-tolerant distributed systems
--
Re-engineering a high frequency e-payment authorization system

Nicolas PENNELLE, Chief Engineer
Gael MIGLIORINI, Solution Architect, Engineer
HPS Worldwide - ACPQUALIFE, 805 Avenue Guillibert Gauthier de la Lauzière, 13290 Aix-en-Provence, France

Françoise BAUDE, Professor, Université de la Côte d'Azur, CNRS I3S
Fabrice HUET, Associate Professor, Université de la Côte d'Azur, CNRS I3S
2000 route des Lucioles 06900 Sophia-Antipolis France.

Context

HPS/Acqualife is a leading world-wide company for supporting electronic payments. HPS PowerCARD product is a robust, open, evolutive solution to handle (i.e. to authorize) electronic payment transactions originating from various terminals, e.g; ATM, mobile, internet: the key PowerCARD operation is to decide to authorize or not a transaction in close to real-time. Authorization is decided by querying both international (Visa, Mastercard, Amex, …), domestic or specific host banking institutions systems and PowerCARD internal data warehouse via SQL stored procedures, and apply specific controls about the requested transaction. The volume of transaction authorizations to handle is of a handful of thousands per second. Next generation of PowerCARD, *PowerCARD Switch* is under specification. It will feature a microservices based architecture (MSA), with the aim to benefit from private cloud hosting, scalability and resilience. The general goal of the industrial PhD is to contribute innovative ideas and solutions in this context.

SCALE is a joint team between CNRS, and Univ. of Nice Sophia Antipolis/Université Côte d'Azur https://scale-project.github.io/ and is a continuation of the former Equipe Projet INRIA *OASIS*. It builds fundamental principles, techniques, and tools allowing implementation, analysis, and verification of reliable and efficient large-scale distributed solutions. Its activities span from formal methods and programming models (actor based innovative models) to practical implementation of applications and middleware. SCALE expertise on distributed programming models, design and implementation of run-time supports for these models, as well as deep knowledge and optimization of third-party solutions (like distributed stream processing systems as Apache STORM) will be crucial for the success of this PhD thesis. The Scale team has also a strong expertise in the design and implementation of applications to run on top of such homemade or third-party middleware, for illustration or benchmarking purposes.

Subject

Successful and smooth migration of multi-tiers and sometimes monolithic architectures to Micro Services Architectures (MSA) is becoming a hot topic in the industry. Success relies on intelligent use of mixture of cutting-edge framework stacks (eg SMACK/Spark-Mesos-Akka-Cassandra-Kafka); from

the application viewpoint the main difficulty, that we want to address as a central research question during this PhD, is the way the micro services should be composed to support specific flows of business operations while ensuring the expected performance level, as the main criteria is to reply to a requested authorization in the given delay. Meeting the availability and expected performance level in any situation, including if the distributed system gets partitioned for any reason, requires supporting vertical and horizontal scalability; but, at the same time, due to the well-known CAP theorem *PowerCARD Switch* will have to incorporate specific solutions to reconciliate service replicas data in the background.

Indeed, in this specific context of being able to respond in real-time to thousands of payment authorizations per second, the flows of Power CARD should feature a high degree of plasticity/adaptability resp. at design, and at runtime. Not only the set of supported flows can be very different from one deployment to another, but also new transaction authorization process can popup, so the system should be highly configurable even once deployed and running. Because of high variability both in the volume and nature of the authorizations to process, it is required to execute on a distributed thus prone to failures system. All such needs call for a resilient programming model. More precisely, the core of the PhD work will be to research an appropriate programming model and associated supporting middleware support, that may incorporate auto-adaptable capabilities to meet the SLA of flows. This of course calls for a reactive programming of the flows (eg reactive workflows [21]) along both data-driven (each transaction is a data to process) and event-driven (asynchronous/reactive property) perspectives, which is recognized to be tricky to play with particularly in case of failures [20]; moreover, we want to envision to introduce self-adaptation of the programmed flows in order for them to better support parallel or alternative paths, or to self-optimize the way they handle streams of transactions (eg. one by one, or in batch, but what batch size in this case). Not only self-adaptation of the data-driven program is needed but this is also important that the supporting middleware (as the message bus) features auto-adaptation capabilities (as in [14]) and that the multi-levels of monitoring and control do interact and collaborate.

In [15] authors mention that reports about experience of migrating a legacy system to a new MSA-based architecture are rare; alas it could be valuable to push further this innovative approach from academia to industry. Consequently, by the end of the PhD, it is also our intention (as in [17]) to publish lessons learned about the PowerCARD system migration process. The particularity we foreseen is that the system to migrate has some peculiar and strong non-functional expectations and SLAs to fulfill, so we believe that the way they will be fulfilled can be valuable in similar mission-critical contexts.

To summarize, the goal of this PhD research work is to contribute to the design and development of PowerCARD next generation central module in charge of the processing of payment authorizations. The module designed along a MSA will exhibit self-capabilities, at all levels.

Work environment, contact, process of application

The work will primarily take place in HPS Worldwide/ ACPQUALIFE located in Aix-en-Provence, under local supervision of Gael Migliorini for HPS and the academic supervision of Pr F. Baude, and Dr F. Huet CNRS/UNS I3S laboratory in Sophia-Antipolis for the Doctoral School. The PhD student will be hired by HPS Worldwide/ ACPQUALIFE.

The student will be registered at the Université Côte d'Azur, Ecole doctorale EDSTIC http://edstic.unice.fr/fr

Contact Nicolas PENNELLE : nicolas.pennelle@hps-worldwide.com – 06.73.52.72.78 and Françoise BAUDE : baude@unice.fr 04 89 15 43 89

The position will be open until filled, interested candidates are invited to send their application as soon as possible. The start of the PhD is expected in Fall 2019. Interested candidates are encouraged to contact the supervisors mentioned above if they have any question, and invited to send the following documents to them:

- a detailed CV,
- a list of courses and grades during the MSc (and if possible earlier years),
- a list of 2-3 references willing to support their application,
- a short statement of interest and any other information useful to evaluate the application.

Relevant References of the team

[1] L. HENRIO, F. HUET, Z. ISTVÁN. Multi-threaded Active Objects, in "COORDINATION 2013", Firenze, Italy, C. JULIEN, R. DE NICOLA (editors), Springer, 2013, 15th International Conference on Coordination Models and Languages, Florence, Italy, 3–6, http://hal.inria.fr/hal-00818482

[2] M. BENGUIGUI, F. BAUDE. American Basket Option Pricing on a multi GPU Cluster, in "22nd High Performance Computing Symposium", Tampa, FL, United States, April 2014, pp. 1-8, http://hal.inria.fr/hal00927482

[3] L. PELLEGRINO, F. HUET, F. BAUDE, A. ALSHABANI. A Distributed Publish/Subscribe System for RDF Data, in "Data Management in Cloud, Grid and P2P Systems", Prague, Czech Republic, A. HAMEURLAIN, P. SABATIER, D. TANIAR (editors), Springer Berlin Heidelberg, August 2013, pp. 39-50, http://hal.inria.fr/ hal-00856737 Denis Caromel and Ludovic Henrio. A Theory of Distributed Objects. Springer-Verlag, 2004.

[4] T.-T. VU, F. HUET. A Lightweight Continuous Jobs Mechanism for MapReduce Frameworks, in "13th IEEE/ACM International Symposium on Cluster, Cloud, and Grid Computing, CCGrid 2013", Netherlands, June 2013, pp. 269-276, http://hal.inria.fr/hal-00916103

[5] M. ANTOINE, L. PELLEGRINO, F. HUET, F. BAUDE. A generic API for load balancing in distributed systems for big data management, in "Concurrency and Computation: Practice and Experience", August 2015 [DOI : 10.1002/CPE.3646], https://hal.archives-ouvertes.fr/hal-01273083

[6] F. BAUDE, L. HENRIO, C. RUZ. Programming distributed and adaptable autonomous components–the GCM/ProActive framework, in "Software: Practice and Experience", May 2014, https://hal.inria.fr/hal01001043

[7] G. SONG, J. ROCHAS, L. ELBEZE, F. HUET, F. MAGOULES. K Nearest Neighbour Joins for Big Data on MapReduce: A Theoretical and Experimental Analysis, in *IEEE Transactions on Knowledge and Data Engineering*, Institute of Electrical and Electronics Engineers, 2016, 28 (9), pp.2376-2392. ⟨10.1109/TKDE.2016.2562627⟩, hal-01406473

[8] F. BAUDE, L. ELBEZE, M. OLIVA. Towards a flexible data stream analytics platform based on the GCM autonomous software component technology, in *The 2016 International Conference on High Performance Computing & Simulation (HPCS 2016)*, Jul 2016, Innsbruck, Austria, hal-01323445

[9] A. PAGLIARI, F. HUET, G. URVOY-KELLER On the cost of reliability in Data Stream Processing Systems, in *IEEE/ACM CCGrid*, 2019, To appear

Relevant References for the proposed subject

[10] Raul Estrada. 2016. Fast Data Processing Systems with SMACK Stack. Packt Publishing. https://books.google.fr/books?hl=en&lr=&id=OM_cDgAAQBAJ&oi=fnd&pg=PP1&dq=%22fast+

data%22+SMACK+&ots=EjifgrNm_o&sig=yfnFh7riO4L1OBXQaFsoIMZtRKU#v=onepage&q=%22fast%20data%22%20SMACK&f=false

[11] Reactive streams https://en.wikipedia.org/wiki/Reactive_Streams

[12] Damian Arellanes , Kung-Kiu Lau " D-XMAN: A Platform For Total Compositionality in Service-Oriented Architectures" 2017 IEEE 7th International Symposium on Cloud and Service Computing

[13] Dinesh Rajput, Rajesh R. Building Microservices with Spring: Master design patterns of the Spring. https://books.google.fr/books?hl=en&lr=&id=JNCBDwAAQBAJ&oi=fnd&pg=PP1&dq=reactive+streams+orchestration&ots=WYY7QcUKMN&sig=nTZ4p_mGPrqcYTBAXXx1pkdnHf4#v=onepage&q&f=false

[14] SmartVM: a SLA-aware microservice deployment framework. WWW journal, Issue 1, Vol 22, Jan 2019 https://link.springer.com/content/pdf/10.1007/s11280-018-0562-5.pdf

[15] Paolo Di Francesco, Patricia Lago, Ivano Malavolta Architecting with microservices: A systematic mapping study. Journal of Systems and Software, Volume 150, April 2019, Pages 77-97 https://www.sciencedirect.com/science/article/pii/S0164121219300019

[16] Abbas Balalaie, Heydarnoori, Pooyan Jamshidi, Damian A. Tamburri, Theo Lynn. Microservices migration patterns - Software: Practice and Experience 2018 - Wiley Online Library https://onlinelibrary.wiley.com/doi/full/10.1002/spe.2608

[17] M. Mazzara, N. Dragoni, A. Bucchiarone, A. Giaretta, S. Larsen, S. Dustdar. Microservices: Migration of a Mission Critical System, IEEE Transactions on Services computing, 2018,

[18] M. Saey. A DSL for Distributed, Reactive Workflows, SPLASH (ACM Annual Conference on Systems, Programming, Languages, Applications: Software for Humanity) 2018, co-located with OOPSLA, ACM

[19] Zhang, S., Mao, X., Liu, P., & Hou, F. A self-Adaptation framework of microservice systems. 30th International Conference on Software Engineering and Knowledge Engineering, SEKE, 2018

[20] R. Mogk, L. Baumgärtner, G. Salvaneschi, B. Freisleben, and M. Mezini, Fault-tolerant Distributed Reactive Programming, 32nd European Conference on Object-Oriented Programming (ECOOP 2018)

[21] Mathijs Saey, Joeri De Koster, and Wolfgang De Meuter. Skitter: A DSL for Distributed Reactive Workflows. InProceedings of the 5th ACM SIGPLAN International Workshop on Reactive and Event-Based Languages and Systems (REBLS '18)