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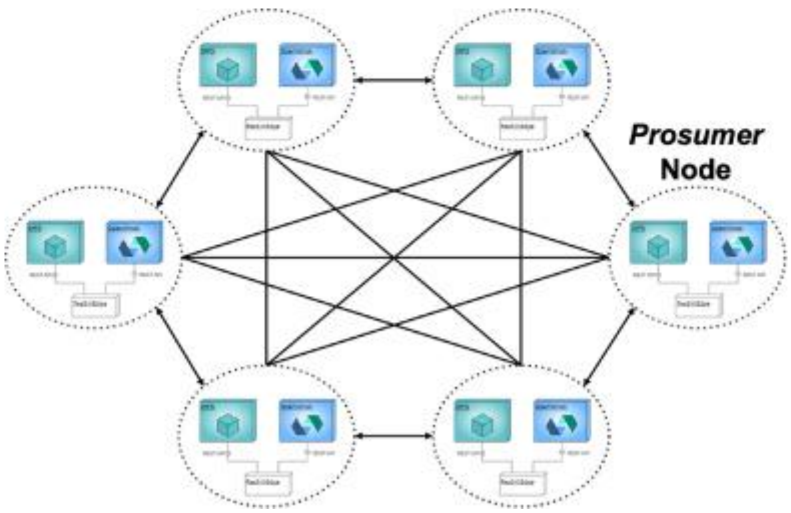

Advances in decentralization, dependability and expressiveness for cloud applications

by Luis Veiga (INESC-ID)

We highlight recent work on supporting Function-as-a-Service (FaaS) in decentralized scenarios[1], on improving efficiency of state management and recovery in BFT applications[2], and comprehensively studying graph databases[3].

The work published in Future Generation Computer Systems[1] extends prior research by presenting an updated Function-as-a-Service middleware for decentralized collaborative edge computing. The proposed system overcomes limitations of cloud-centric and hierarchical edge architectures, such as latency, scalability, and reliance on centralized coordination, by enabling serverless function execution across volunteered edge nodes. It integrates Apache OpenWhisk with IPFS to support peer-to-peer resource discovery, deployment, and execution in heterogeneous and dynamic environments. Experimental results show high submission and invocation success rates with competitive latency, demonstrating the practicality of fully decentralized serverless computing for IoT and other latency-sensitive applications, while promoting scalability, resilience, and autonomy at the edge.

We continue with an algorithmic approach to improve state transfer efficiency[2] in Byzantine Fault Tolerant (BFT) State Machine Replication (SMR) systems, recently published in the Journal of Parallel and Distributed Computing. In BTF-SMR, replica recovery requires transferring application state that may exceed available memory, causing significant performance bottlenecks. We introduce the concept of divisible state and propose Progressive State Transfer, which partitions large states into smaller components that can be fetched in parallel from multiple replicas. Combined with a differential checkpointing mechanism that transfers only modified partitions, the approach significantly reduces redundant data movement. Experimental results demonstrate up to an order-of-magnitude improvement in recovery time compared to traditional checkpointing, advancing the scalability and practicality of fault-tolerant distributed systems with large state sizes.

We conclude by discussing ongoing research on graph databases[3], which have emerged as a fundamental technology for managing highly interconnected data in domains such as social networks, bioinformatics, recommendation systems, and AI-driven applications. While graph databases offer natural and efficient modeling for relationship-centric workloads, they face challenges related to data irregularity, traversal complexity, and scalability limitations of centralized architectures. We survey graph databases examining their core components, including data models, query languages, and storage architectures, and analyzing recent advancements across system design and deployment. By synthesizing insights from existing platforms and prior studies, we identify key design tradeoffs and provide guidance for selecting graph database technologies, while outlining emerging trends driven by large-scale data and AI workloads.

[1] Catarina Gonçalves, José Simão, Luís Veiga. A function-as-a-service middleware for decentralized collaborative edge computing. Future Generation Computer Systems, Volume 175, February 2026, 108069
https://doi.org/10.1016/j.future.2025.108069

[2] Amadeu Marques, Nuno Neto, Rolando Martins, Luís Veiga. Progressive State Transfer for BFT With Larger-than-Memory State. Journal of Parallel and Distributed Computing, 105215
https://doi.org/10.1016/j.jpdc.2025.105215

[3] Miguel E Coimbra, Lucie Svitáková, Domagoj Vrgoč, Alexandre P Francisco, Luís Veiga. Survey: Graph Databases - On the Landscape of Graph Databases. *Submitted to* Foundations and Trends® in Databases. *(under review)*

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