MASSIVIZING COMPUTER SYSTEMS

SERVERLESS COMPUTING IN THE CONTINUUM -OR-
WHEN I'LL STOP WORRYING AND LEARN TO LOVE SERVERLESS

@Large Research
Massivizing Computer Systems

http://atlarge.science

Serverless computing =
Extreme automation + fine-grained, utilization-based billing

bit.ly/ServerlessContinuum22

Contributions from the MCS team. Many thanks!
Many thanks to our collaborators, international working groups, authors of all images included here.
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THIS IS THE GOLDEN AGE OF COMPUTER ECOSYSTEMS
THIS IS THE GOLDEN AGE OF MASSIVE COMPUTER ECOSYSTEMS

Big Science

Education for Everyone (Online)

Business Services

Big Data

Internet

5G/6G/

THz

VLC

Online Gaming

Datacenter

Cloud Computing

Edge Computing

BUT WE CANNOT TAKE THIS TECHNOLOGY FOR GRANTED

(So, this is why I am giving this talk)
PHENOMENON: FAILURES IN CLOUD SERVICES

UNCOVERING THE PRESENCE OF FAILURES

Source: gamenewstoday.com
PHENOMENON: PERFORMANCE IN CLOUD SERVICES

UNCOVERING THE PRESENCE OF PERFORMANCE ISSUES, EVEN LEADING TO CRASHES


Players in Eve Online broke a world record — and then the game itself

Developers said they’re not ‘able to predict the server performance in these kinds of situations’

By Charlie Hall | @Charlie_L_Hall | Jan 5, 2021, 2:54pm EST

Source: Razorien/CCP Games
PHENOMENON: CLOUD DATACENTER SUSTAINABILITY

UNCOVERING THE USE OF ENERGY AND WATER, THE IMPACT ON CLIMATE

Power consumption of datacenters:

- **>1% of global electricity**
  

- **1→3% of national electricity** in the Netherlands
  
  Source: NRC, 2019 [Online]

Water consumption of datacenters in the US:

- **>625Bn. l/y (0,1%)**
  
  Source: Energy Technologies Area, 2016 [Online]

Other greenhouse emissions:

- **Largely unknown**
  
  Source: Nature Climate Change, 2020 [Online]
THIS TALK, IN A NUTSHELL

Serverless =
1. Extreme automation
2. Fine-grained reporting / utilization-based billing
Serverless can only be achieved through complex, smart computer ecosystems (operational simplicity is for the user)
AN ANALOGY: MASSIVIZING CLIMATE SCIENCE

TAKE A HOLISTIC VIEW, BASED ON COUPLED NATURAL SYSTEMS

* In climate science, issues are often linked. The same occurs in massive computer (eco)systems.

Source: HPCWire

Can be understood only with coupled models
A TYPICAL ECOSYSTEM: SERVICE, DATACENTER, SCHEDULER

Creators → Digital Services → Resource Manager and Scheduler → Datacenter

100s of services... an ecosystem

Performance, Dependability, Sustainability

Source: Google
50+ PLATFORMS ... EMERGENT FEATURES

THE COMPLEXITY CHALLENGE

REFERENCE ARCHITECTURE OF FAAS PLATFORMS

Workflow Composition Layer
- Workflow Registry (W1)
- Workflow Engine (W2)
- Workflow Scheduler (W3)
- Workflow Execution Store (W4)

Function Management Layer
- Function Registry (F1)
- Function Builder (F2)
- Function Deployer (F3)
- Function Instance (F4)
- Function Router (F5)
- Function Autoscaler (F6)

Resource Orchestration Layer
- Naming Service (R1)
- Resource Manager (R2)
- Resource Scheduler (R3)
- Node Agent (R4)

[van Eyk et al. (2019) Serverless is More: From PaaS to Present Cloud Computing, IEEE Internet Computing] [Online]
Actual ML app is a very small part!

Adapted from:
BEYOND THE DATACENTER: THE COMPUTING CONTINUUM

THE COMPLEXITY CHALLENGE

REFERENCE ARCHITECTURE OF FAAS PLATFORMS

Jansen et al. (2022) Ongoing Work
SERVERLESS ... WHAT COULD BE THE BENEFITS?

TOO COSTLY TO CONDUCT REAL-WORLD EXPERIMENTS, SO WE BUILT A SIMULATOR

- Short-term resource management
- Long-term capacity planning
- Sophisticated model
- Support for many kinds of workloads and resources
- Validated for various scenarios
- Work with major NL hoster
- Used in training

Learn more: opendc.org

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Serverless should be concerned with modern non-functional properties, observed continuously, addressed short- and long-term.
HOW TO ACHIEVE FINE-GRAINED BILLING AND UTILIZATION-BASED BILLING?

THE COMPLEXITY CHALLENGE

REFERENCE VIEW ON OPERATIONAL TECHNIQUES

Metrics to be measured by provider\(^{(P)}\) or IaaS customer\(^{(C)}\)

- Operational risk\(^{(C)}\), ...
- Aggregate metrics\(^{(C)}\), e.g., unit-free scores, speedup ratios, ...
- Performance isolation\(^{(P)}\), elasticity & scalability\(^{(C)}\), energy efficiency\(^{(P)}\), ...
- Resource utilization averages\(^{(P)}\), latency\(^{(P)}\), congestion times\(^{(P)}\), ...

Metrics for Managerial Decisions

- Total cost of ownership\(^{(E)}\), ...
- Policy Metrics
  - SLO Violation rates\(^{(E)}\), service costs\(^{(E)}\), ...
- Cloud Infrastructure Metrics
  - Performance variability\(^{(E)}\), resource availability\(^{(E)}\), ...
- Traditional Performance Metrics
  - Throughput rates\(^{(E)}\), end-to-end response times\(^{(E)}\), ...

Metrics measurable for end-user\(^{(E)}\)

One of the first serverless workflow management engine, part of Fission.io
Fission Workflows delivers good performance, which also lowers cost.
Serverless = Extreme automation + fine-grained reporting + utilization-based billing

The serverless ecosystem: many apps, many platforms, many goals, many approaches

Many modern, open challenges: scheduling, telemetry, recovery, privacy/GDPR, etc.
1. Iosup et al. Massivizing Computer Systems. ICDCS 2018 ← start here
2. Andreadis et al. A Reference Architecture for Datacenter Scheduling, SC18
13. Iosup et al. The OpenDC Vision. ISPDC’17.
15. Iosup et al. LDBC Graphalytics. PVLDB 2016.
Etc.
1. Iosup et al. The AtLarge Vision on the Design of Distributed Systems and Ecosystems. ICDCS 2019 ← Start here
5. van Beek et al. Portfolio Scheduling for Managing Operational and Disaster-Recovery Risks in Virtualized Datacenters Hosting Business-Critical Workloads. ISPDC 2019
6. van Beek et al. A CPU Contention Predictor for Business-Critical Workloads in Cloud Datacenters. HotCloudPerf19

Etc.
5. Uta et al. (2020) Beneath the SURFace: An MRI-like View into the Life of a 21st-Century Datacenter. login USENIX
US IN 1 MINUTE
WE’RE MASSIVIZING COMPUTER SYSTEMS!
Amsterdam
founded 10th century
pop: 850,000

VU
founded 1880
pop: 23,500

The Netherlands
pop: 16.5 M

Europe
WE ARE A FRIENDLY, DIVERSE GROUP, OF DIFFERENT RACES AND ETHNICITIES, GENDERS AND SEXUAL PREFERENCES, VIEWS OF CULTURE, POLITICS, AND RELIGION. YOU ARE WELCOME TO JOIN!

WE ARE LOOKING FOR A NEW ASST. PROF.!
MASSIVIZING COMPUTER SYSTEMS: OUR MISSION

http://atlarge.science/about.html

1. Improve the lives of millions through impactful research.
2. Educate the new generation of top-quality, socially responsible professionals.
3. Make innovation available to society and industry.
EXTRAS
THE ECONOMIC IMPACT OF MASSIVE COMPUTER ECOSYSTEMS

ECONOMY AND SOCIETY ARE BUILT ON DIGITAL

€460 MLD
DIGITAL VALUE

3.3 MLN
JOBS CREATED

56%
JOB GROWTH
2019-2024

DIVERSE SERVICES FOR ALL

EVERY €1 → €15 ADDED VALUE

Impacting >60% of the NL GDP (1 trillion EUR/y)

Attracting >20% of all foreign direct investments in NL

What is a Distributed Ecosystem?

Our definition

1. Set of 2+ constituents, often heterogeneous
2. Each constituent is a system or an ecosystem (recursively)
3. Constituents are autonomous, cooperative or in competition
4. Ecosystem structure and organization ensure responsibility
   1. Completing functions and providing services
   2. Providing desirable non-functional properties
   3. Fulfill agreements with both operators and clients, clients in the loop
5. Long and short-term dynamics occur in the ecosystem

Iosup et al., Lecture Notes in Distributed Systems, Section 1.1.1

Iosup et al., Massivizing Computer Systems, ICDCS 2018. [Online]
Massivizing Grand Challenges

A larger vision of how computing will help our society

- Ecosystems of Data and App Markets
- Development Platforms
- Runtime Engines
- Resource Management
- Operating and Foundational Services
- Compute, Memory, Storage, & Network Infrastructure

Simplicity and Maintainability
Responsibility, Trust, and Security
Energy Efficiency & Sustainability
Digitalization
Integration with EU tech platforms and societal goals

Societal challenges in the NL

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