

MASSIVIZING COMPUTER SYSTEMS – THE ICT INFRASTRUCTURE MEMEX

VU ON THE DIGITAL COMPUTING CONTINUUM

@Large Research
Massivizing Computer Systems <http://atlarge.science>

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Contributions from the MCS@Large teams. Many thanks! Many thanks to our collaborators, international working groups, authors of all images included here. Also thanks to Radu Prodan, Martina Steinbacher, Dragi Reza, and the KLU team.

VU VRIJE
UNIVERSITEIT
AMSTERDAM

GRAPH MASSIVIZER
Rijksoverheid
NWO

Continuum = infrastructure for the 21st century, different from what we had before

Prof.dr.ir. Alexandru IOSUP

1

@L US IN 3 MINUTES

WE'RE MASSIVIZING COMPUTER SYSTEMS!

2

VU AMSTERDAM < SCHIPHOL < THE NETHERLANDS < EUROPE

Amsterdam founded 10th century pop: 850,000

VU founded 1880 pop: >25,000 (~ 5,000 staff)

The Netherlands Europe

VU UNIVERSITY
AMSTERDAM

3

Massivizing Computer Systems

Research Group Bio
<https://atlarge-research.com>

Group Bio: CompSys | Massivizing Computer Systems group | National/EU projects, incl. NL Grootfondsprogramma 6G Future Network Services (€315M / 7 years), NL NWO OffSense, EU Horizon Graph-Massivizer (€5M), EU MCSA-RISE CLOUDSTARs Serverless ± virtualized cloud environments: RM&S for workflow and serverless ops, back-end services, aggregate and disaggregate resources, compute and IO, VM/Containerization and JIT compiling, performance, availability, energy, Understand and Experiment / analyze / benchmark ecosystems, design new parts, improve existing parts, share FAIR tools + Memex-like data.

Digital Twin: ICT infrastructure/datacenter simulation, Operational Data Analytics, DC cockpit, VR/XR ops.

Relevant prior work (selection of tools and activities):

Serverless history + vision	OpenDC simulator	K8s/Storage benchmark	Continuum + Reference Archi	LDBC GRAPHALYTICS	spec Research
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Contact: info@atlarge-research.com

4

<http://atlarge.science>

CURRENT TEAM

ALUMNI

VISITORS

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

5

WHO AM I?
PROF. DR. IR. ALEXANDRU IOSUP

- Education, my courses:
 - > Honours Programme, Computer Org. (BSc)
 - > Distributed Systems, Cloud Computing (MSc)
- Research, 15 years in DistribSys:
 - > Massivizing Computer Systems
 - > About 30 young researchers in the team
- About me:
 - > Worked in 7 countries, NL since 2004
 - > I like to help... I train people in need
 - > VU University Research Chair + Group Chair
 - > NL ICT Researcher of the Year
 - > NL Higher-Education Teacher of the Year
 - > NL Young Royal Academy of Arts & Sciences
 - > Knighted in 2020

VU

7

SINCE LAST YEAR – RE-BOOTED THE COMPSYS NL COMMUNITY...

IJPN IJN
RESEARCH
PLATFORM
NETHERLANDS

SIG FCSN + Manifesto on

Computer Systems and Networking Research

Clear vision for the field in the NL, 2021-2035

Signed
50 Pls / Leads
07 universities
05 relevant societal
stakeholders

Available
Full version <https://arxiv.org/pdf/2206.03259.pdf>
Who's Who In CompSysNL? <https://bit.ly/CompSysNLWhosWho>

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8

8

ONE CONFERENCE TO MENTION... <https://2024.ccgrid-conference.org/>

CCGRID 2024

Philadelphia, USA
May 5-9, 2024

The 24th IEEE/ACM international Symposium on Cluster, Cloud and Internet Computing



The image shows the Philadelphia skyline across the Schuylkill River. The city's modern skyscrapers, including the One Liberty Place and the Comcast Technology Center, are reflected in the water under a bright blue sky with scattered white clouds.

Program Chairs

Alexandru Iosup, Vrije Universiteit Amsterdam, Netherlands
Xiaohui Wang, Temple University, USA
Beth Plale, Indiana University, USA

1. Hardware Systems and Networking
2. Software Systems and Platforms
3. Machine Learning (ML) for Systems and Systems for ML
4. Future Compute Continuum and Seamless Ecosystems
5. Applications and Workflows
6. Performance Monitoring, Modeling, Analysis, and Benchmarking
7. Distributed and Parallel Storage Systems
8. Education about Cluster, Cloud and Internet Computing

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9

THIS IS THE GOLDEN AGE OF COMPUTER ECOSYSTEMS

10

11

12

The diagram illustrates the transition from complex, non-technical issues to a modern distributed computing architecture.

ISSUES: COMPLEXITY, NON-TECHNICAL

Endpoint (represented by a smartphone icon) connects to **Edge** (represented by a cloud icon labeled 'A') which then connects to **Cloud** (represented by a large green cloud icon). A blue arrow points from the Edge to the Cloud, indicating increasing resource constraints and latency.

Increasing Resource Constraints
Increasing Scale, Bandwidth and Communication Latency to Endpoints
Owned by Users (Endpoint)
Owned by Service Providers (Edge, Cloud)

Endpoint (P1)
Data Preprocessing (P2)
Application (P3)
Operating System and Resource Manager (P4)
Infrastructure (P5)

Edge (E1)
Application (E2)
Back-end (E3)
Resource Manager (E4)
Operating Services (E5)
Infrastructure (E6)

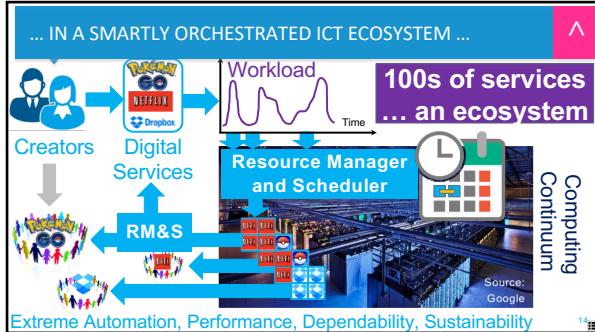
Cloud (C1)
Application (C2)
Back-end (C3)
Resource Manager (C4)
Operating Services (C5)
Infrastructure (C6)

Mist Computing
Edge Computing - Multi-access Edge Computing - Fog Computing
Mobile Cloud Computing
Mobile Cloud Computing

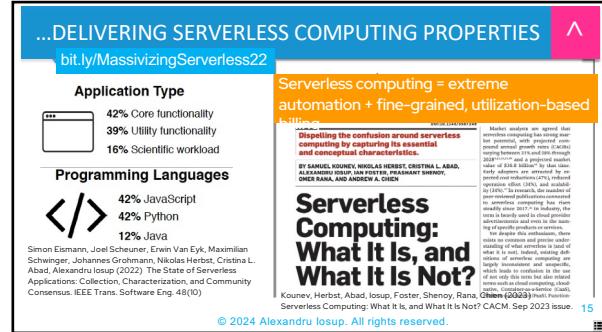
Jansen, Alkis, Dimitris Papadopoulos, Trivedi, Bal, Isopur (2022). The SPEC® Edge Computing CGEN2020. Open access: <https://doi.org/10.48550/ARXIV.2027.04595>

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13



14

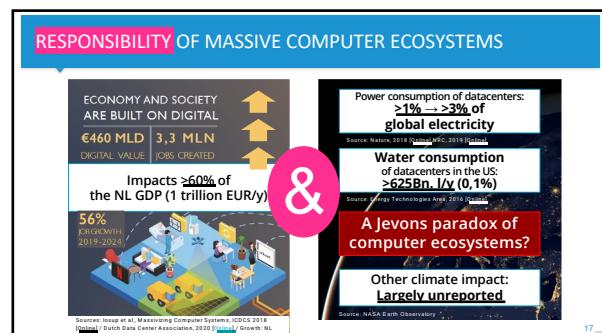


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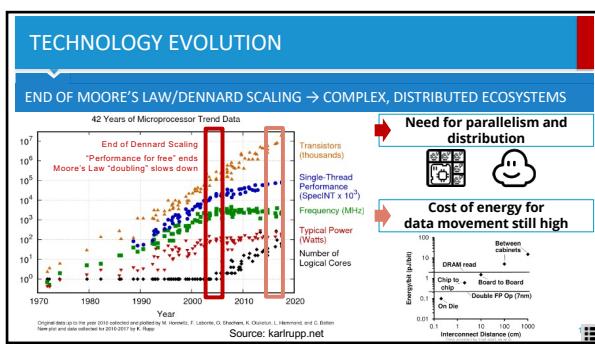
BUT WE CANNOT TAKE THIS TECHNOLOGY FOR GRANTED

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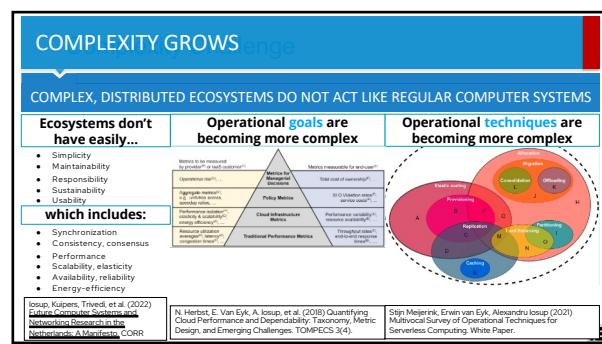
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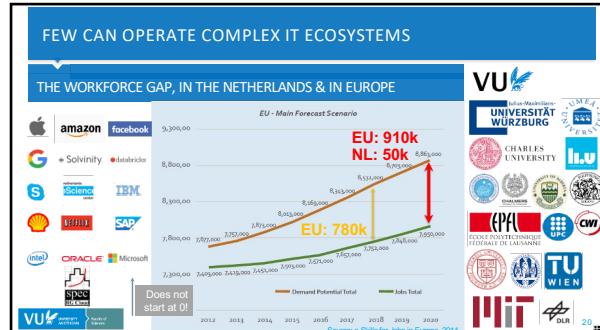
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20

PHENOMENON: PERFORMANCE IN CLOUD SERVICES

UNCOVERING THE PRESENCE OF PERFORMANCE ISSUES, EVEN LEADING TO CRASHES

Polygon
Source: <http://bit.ly/EveOnline21Crash>

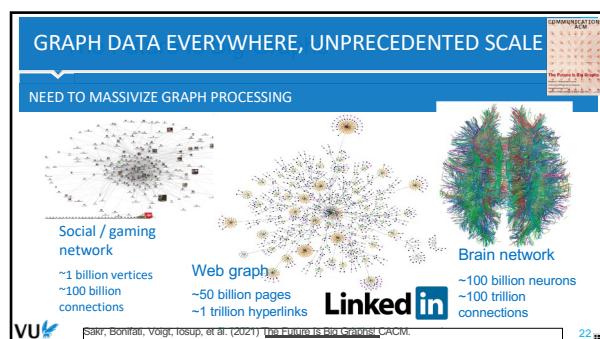
Players in Eve Online broke a world record — and then the game itself

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

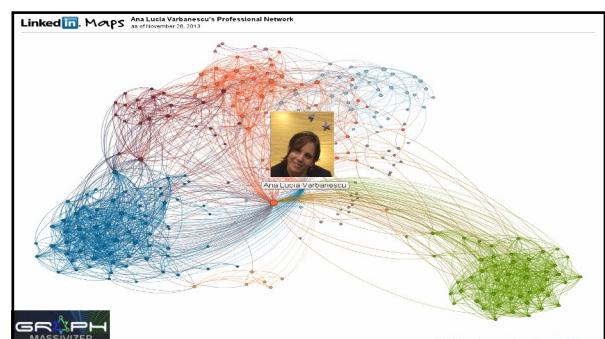
By Charlie Hall | @Charlie_L_Hall | Jan 5, 2011, 2:54pm EST

Source: Razoria/CCP Games

21



22



23



24

IN THIS TALK: INTRO TO THE DIGITAL / COMPUTING / EDGE-CLOUD CONTINUUM

(What do we need in CompSys infrastructure for the 21st century)

3

25

ONE PROJECT TO MENTION...

**Big Graph Processing: Used in [AI/ML] FinTech
ICT Infra., Industry 4.0, Energy Mgmt., etc.**

Vision: Massivizing computer systems approaches are key to enable big graph ecosystems

Graph MASSIVIZER

Graph-Massivizer EU Horizon project (starting 2023)

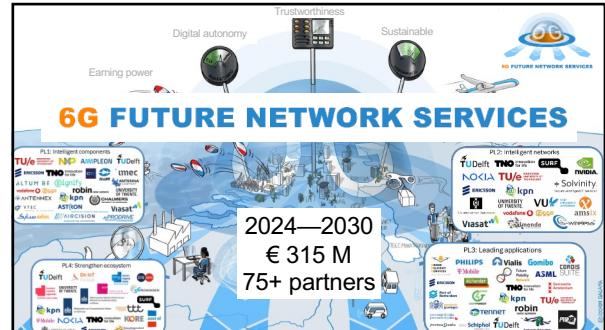
Graph-Massivizer EU Horizon project (starting 2023)

(*) Digital twin for datacenters, with partners CINECA, UniBo, etc.

26

Sakr, Bonatti, Vugl, Iosup, et al. (2021) [The Future Is Big Graphs](#), ACM.

26



27

Objectives AND KEY TECHNOLOGIES FOR A 6G DevOps PLATFORM & DIGITAL TWIN

Phase 1: 2024–mid-2026

Reduce complexity for app providers and network operators through a comprehensive DevOps platform, including a 6G Digital Twin.

Toolchains for app providers → D2.2.1 6G DevOps Platform → Demonstrator

- T2.2.1 6G-ready app development
- T2.2.2 Declarative app deployment and operation
- T2.2.3 App testing and life-cycle management

Toolchains for network operators → D2.2.1 6G Digital Twin → Demonstrator

- T2.2.4 Models & simulation for a 6G Digital Twin
- T2.2.5 Intent-based networking & explainability
- T2.2.6 Resilient & secure network evolution

28

28

Message 4

A new way of thinking about continuum systems

35

Traditional system models in computing

- System and the systems view
- Computer network
- Operating system
- Computer system (from CO course)

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36

36

How well do previous system models match this?

Computing continuum (over)view

Cloud

Edge nodes

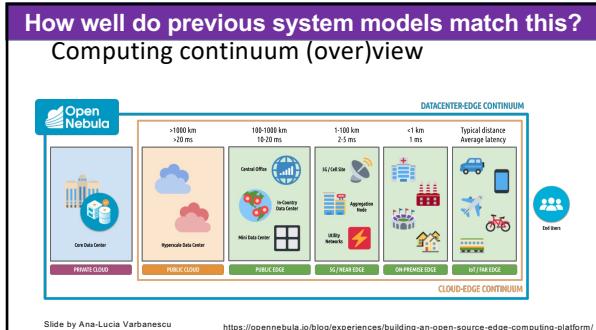
Edge devices

Slide by Ana-Lucia Varbanescu

<https://futuresoftech.com/edge-computing-101/>

37

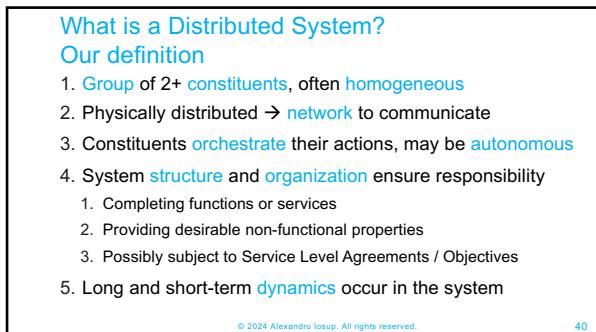
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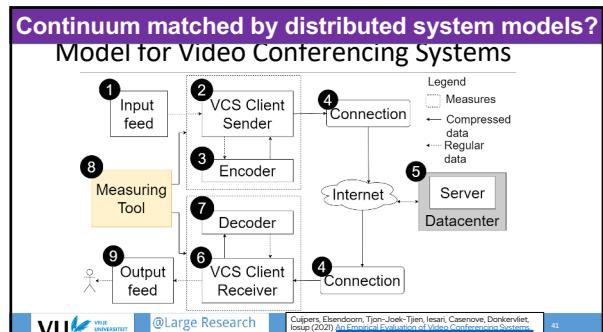
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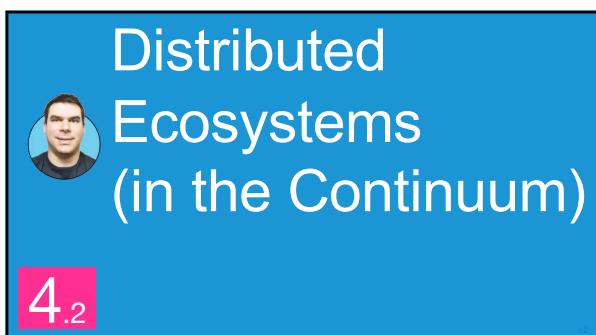
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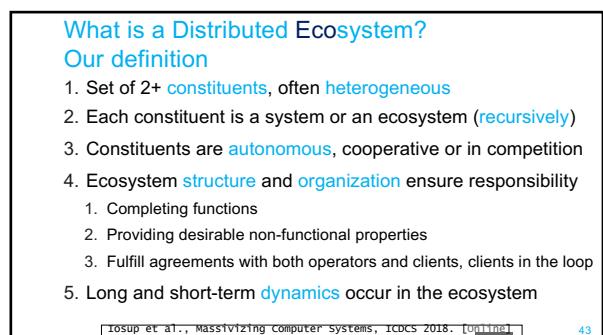
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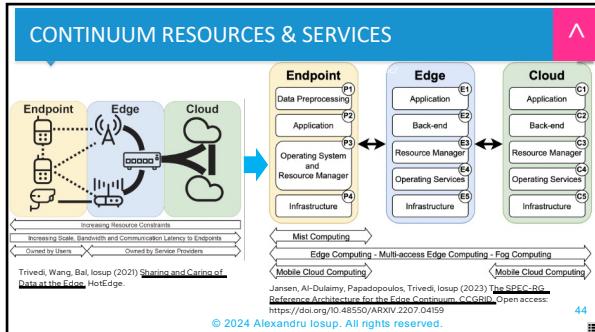
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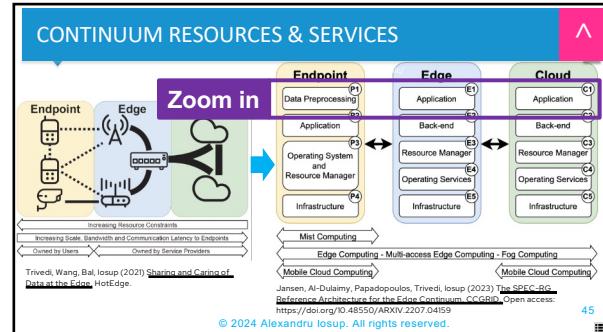
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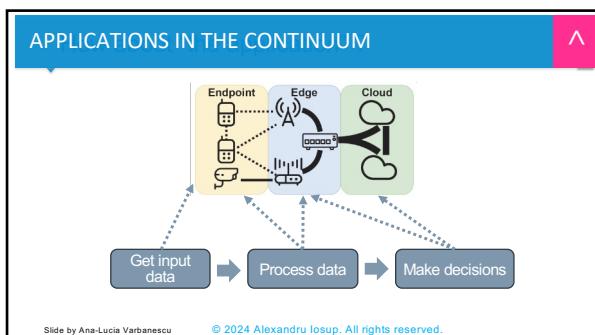
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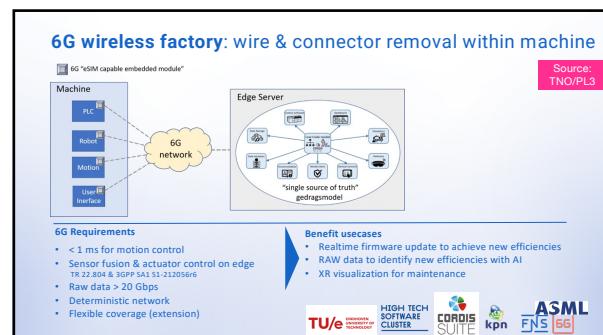
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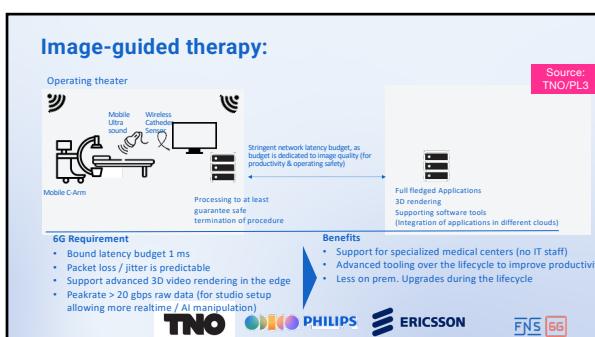
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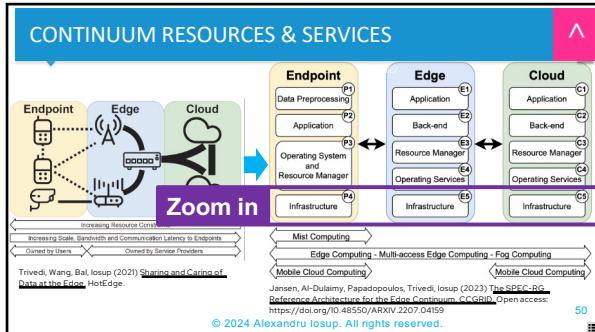
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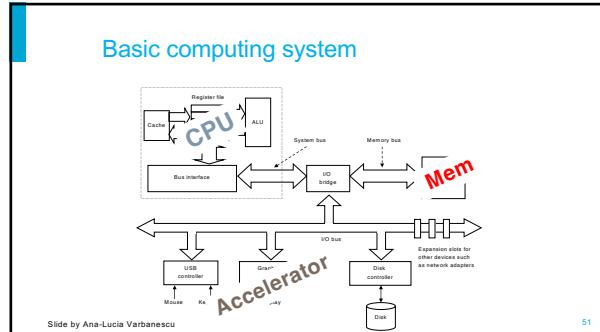
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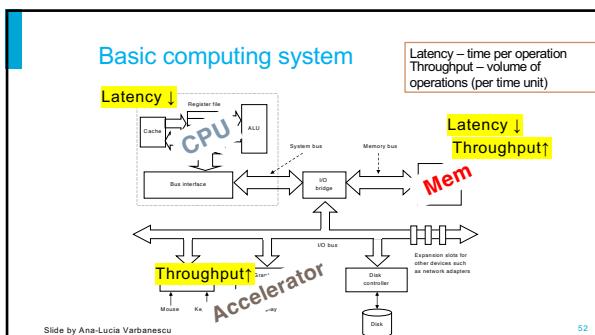
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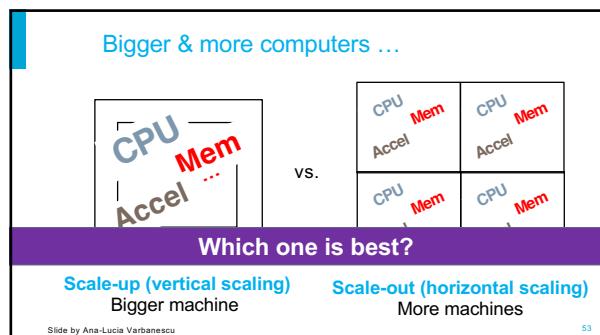
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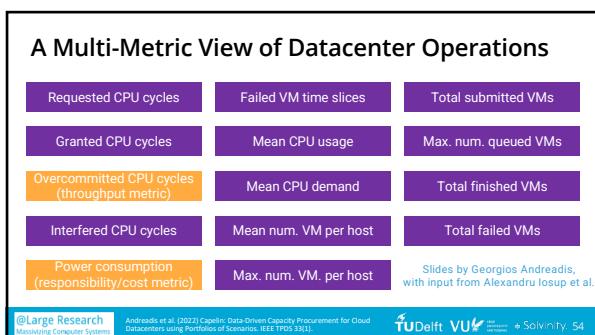
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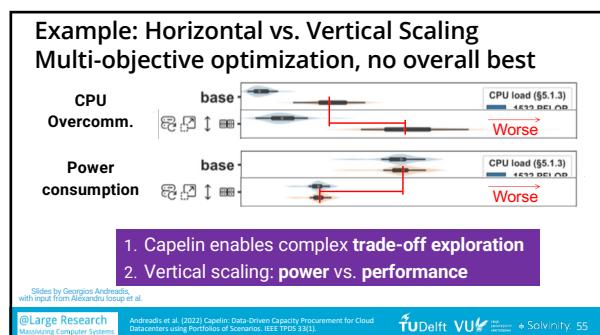
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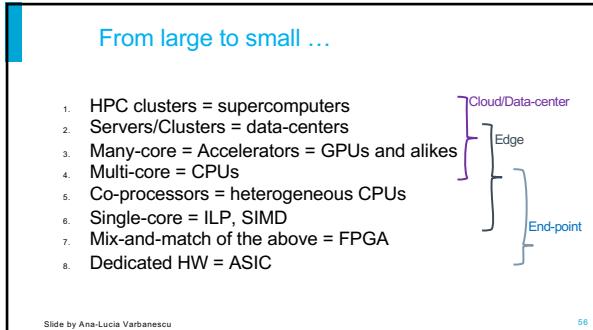
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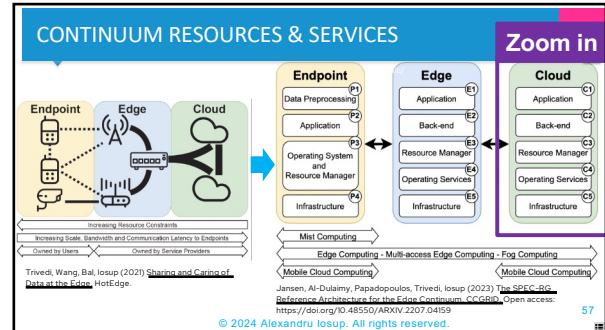
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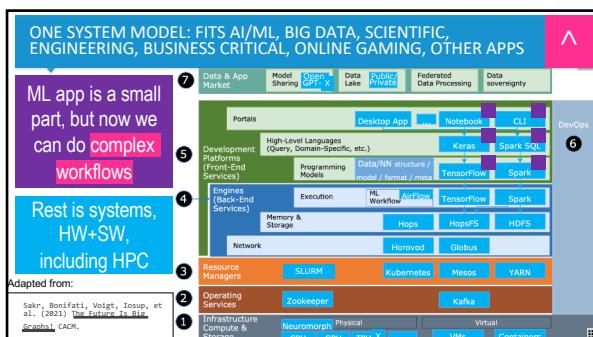
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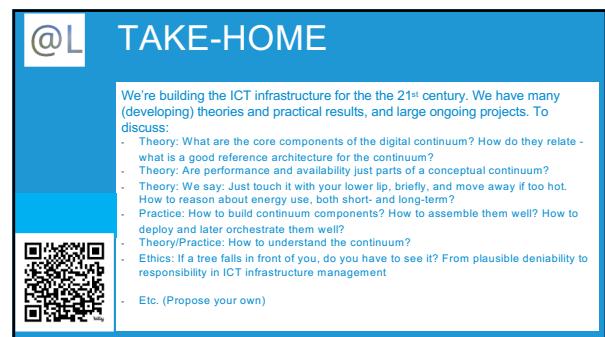
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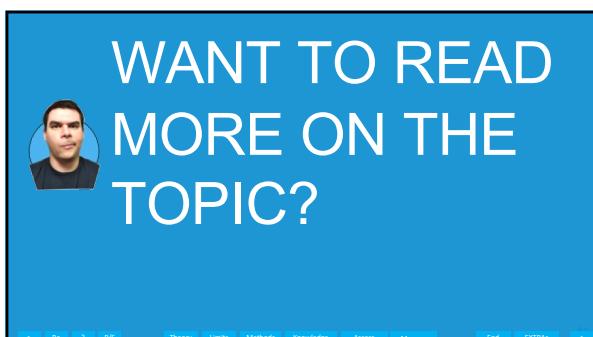
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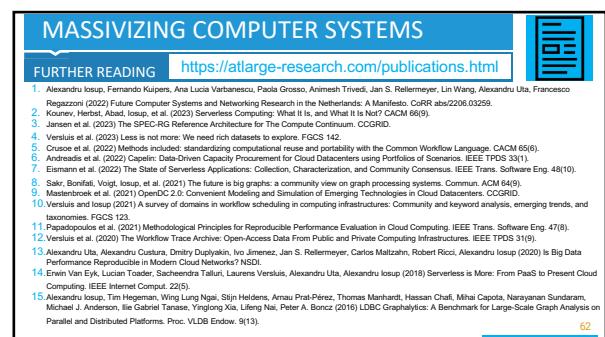
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60



61



62