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Wirth's Law in the Age of Cloud and Green IT

Addressing Software Complexity for Sustainable Performance

Speaker

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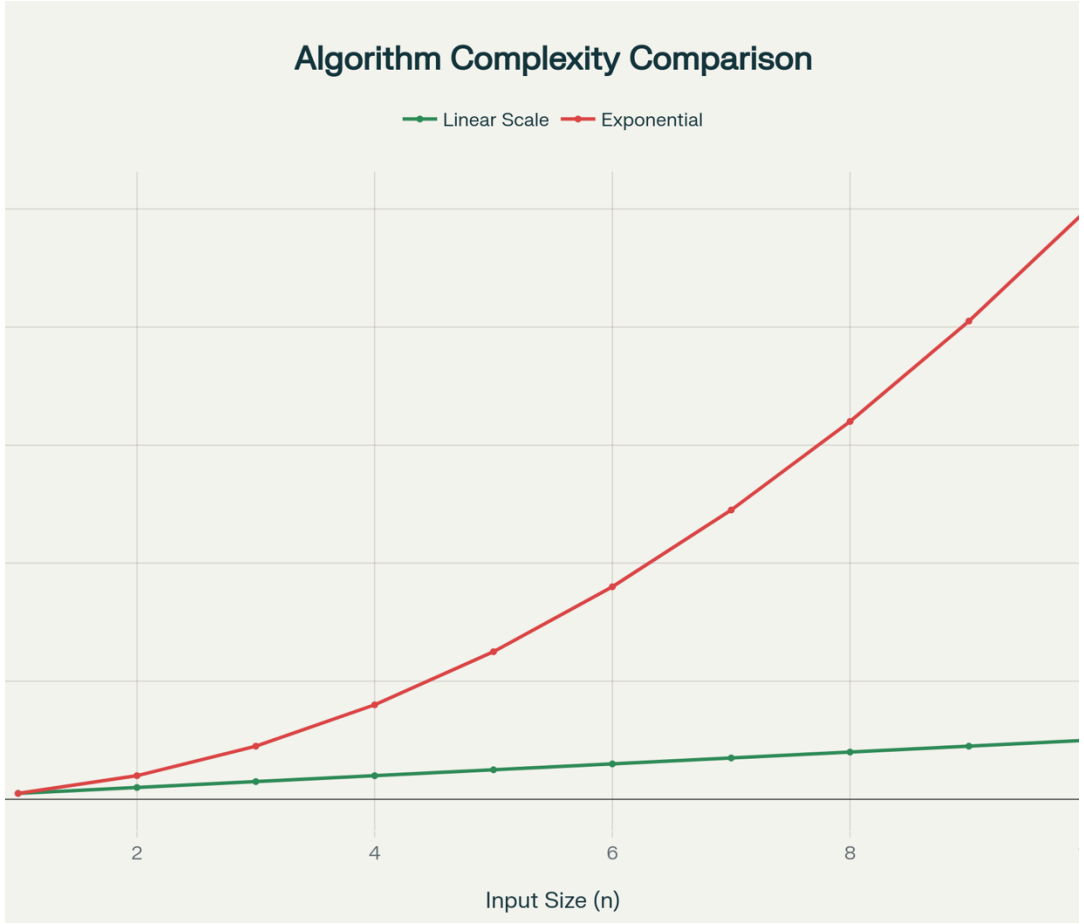
Wirth's Law

Software gets slower more rapidly than hardware becomes faster.

Wirth's Law & The Lost Linearity

THESIS: The Past: Linear scaling with complexity: O(n) vs. Today: Exponential complexity: O(n^2)



The Past:

Software in the 90‘s on DOS machines = single threaded, nearly linear dependency to cpu clock rate

e.g.: DOS Game on 486 @ 33 MHz has 25 fps, but >50 fps @ 66 MHz

Today:

Software often multithreaded, multitasking OS, runs on CPU & GPU = overhead by multithreading + abstraction layers + async I/O

Why the Complexity Exploded

- **Multithreading Overhead:**
  - more CPU cores != more speed
  - more coordination, more waiting for locks, more 'management' work by the operating system
- **Abstraction Layers:**
  - e.g. frameworks, containers, virtual machines
  - additional computational costs per layer – often with complexity O(n^2)
- **Distributed Systems:**
  - interprocess & network communication (with serialization and en/decrypting overhead)
  - RPC and microservice architectures add unpredictable latency

My First Story: The Complexity Trap

Project: PHP-based worktime tracking and work shift management system of a government agency with >10.000 users.

- Starting point: 1 Server → Fast App with < 1s response time
- After 8 years: 24+ Servers → Slow App with > 10s response time

First examination results:

Issue #1: SQL Query with 12.000 lines!
Issue #2: PHP-Monolith with code inside MySQL DB
Issue #3: Each session reads all user data on each request of the UI
Issue #4: Nobody ever checked for slow queries and architecture flaws

Key problem:

Architecture with no segregation of responsibilities and no support for (real) concurrent workloads.

My Second Story: The Cloud Shock

Project: Java-based self-written ERP-System with >5.000 users migrated from on-premises VMs to cloud with „shift-left“ approach.

- Starting point: 5-10 Server on-premises → budget of 250.000 EUR/year and 4 admins
- After migration: all VMs cloud hosted → bill of 1.2 Mio EUR/year for cloud + some on-premises servers + 4 admins

First examination results:

Issue #1: High RAM Usage of Java-App, memory leaks of Tomcat
Issue #2: High idle CPU load
Issue #3: Default Tomcat-Config & Spring (Boot) Setup
Issue #4: Full-blown Linux server OS inside VM

Key problem:

Lift-and-shift workloads often miss 72% potential CO2 reduction (and accordingly the targeted cost reduction).
→ see: 451 Research for AWS, "The carbon reduction opportunity of moving to AWS," 2021

The Deeper Cost:
The Green IT Connection

Pay-per-use means pay-per-waste.

Cloud: You pay for what you use

→ vCPU+vRAM+Storage+DB+Traffic accounted per minute

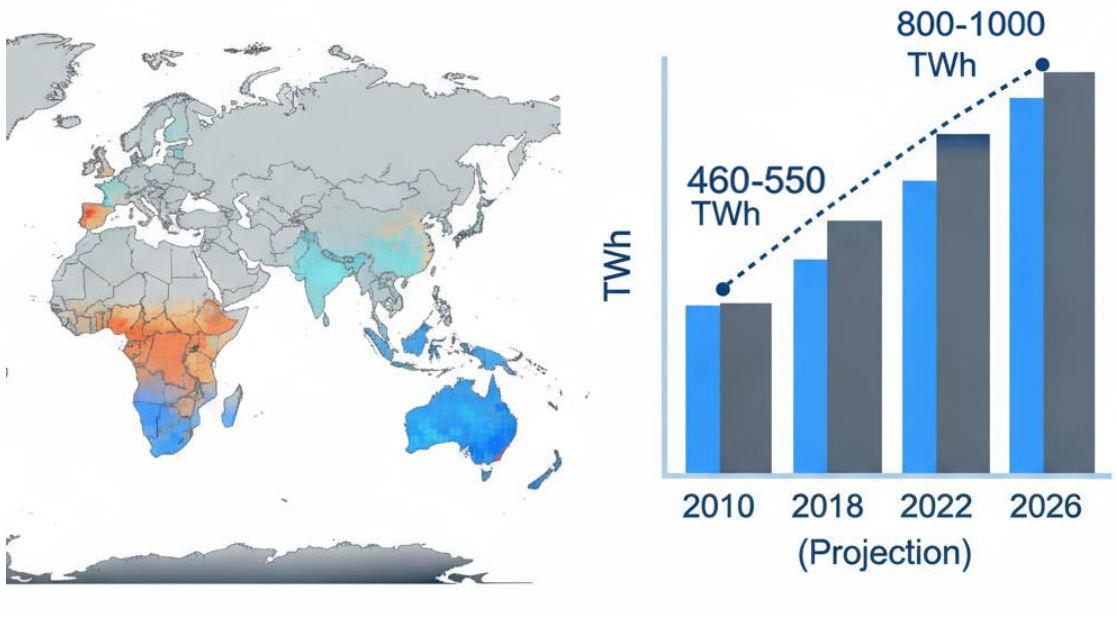
→ every component in cloud environments MUST be resource-efficient

→ software must be designed to prevent CPU load during idle state and inefficient code

Global Reality Check: Datacenter Footprint

Key statistics

- 2022 Consumption: 460–550 TWh (nearly France's electricity demand)
- Ireland: Datacenters use 18% of national grid (2023)
- Projection: Global load could double by 2026 without efficiency gains.



The macro backdrop for Wirth's Law:
Our software choices show up in national energy statistics.

Measuring Sustainability: PUE, SCI & Workload Efficiency

Key metrics

- PUE (Power Usage Effectiveness): Hyperscaler ~1.1 vs. on-premises ~1.6
- SCI (Software Carbon Intensity): `SCI=(E*I)/R` (kg CO2 per user action)
- Workload Efficiency: CPU utilization, autoscaling adherence, idle hours

Effects of workload tuning
Studies by McKinsey and Uptime Institute in 2023 show software-driven workload tuning delivers **10–30% energy and cost reductions**, even in efficient facilities.

Strategy 1: Analyze & Optimize

You cannot optimize what you do not measure.

- PUE (Power Usage Effectiveness): Hyperscaler ~1.1 vs. on-premises ~1.6
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The Quick Win: Configuration is Code

- Tomcat Configuration
  - **Before:** Default Config → increasing RAM-usage = high costs
  - **After:** garbage collector & stack sizes optimized → costs reduced by over 60%, cpu-hours by almost 50%.
- SPRING framework
  - **Before:** full blown config with default settings
  - **After:** switched to Spring Boot with customized profile → reduced RAM-footprint by 25-30%, faster startup-times, lower memory costs

Strategy 2: Architect for Simplicity

The Architectural Fix: Modularization & CQRS for PHP app

Key Architectural Changes:

- Modularization:
  Breaking the monolith into smaller, independent modules.
- CQRS:
  Separating 'write' operations from 'read' operations for independent optimization.
- MVC & Template framework:
  Separating code for generating UI and business logic.

Result:

- From 24+ Servers -> 1 VM
- From Seconds -> Milliseconds (page load times)

Strategy 3: Modernize Platforms

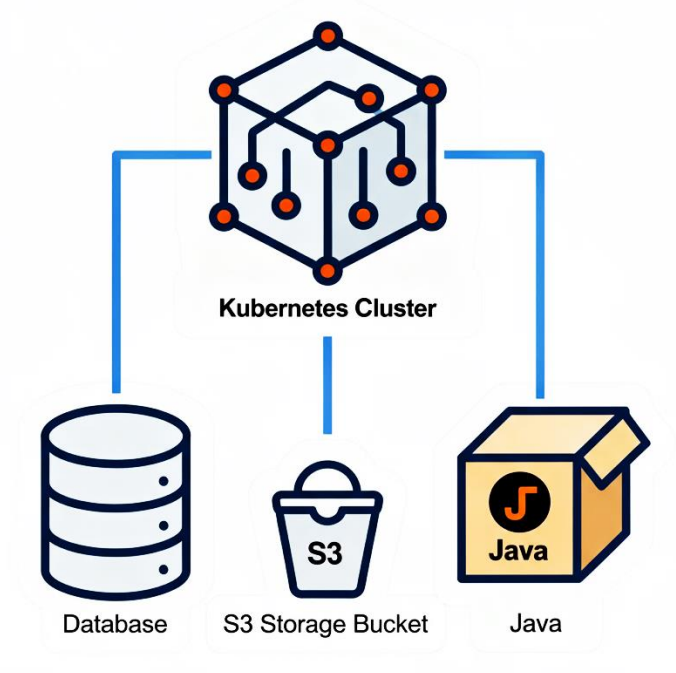
Leveraging Modern Technologies

Key Infrastructure Changes:

- Containerisation:
  Deploy the Java ERP as Containers in Kubernetes, instead of VMs
- Kubernetes & Stages:
  New Stages for Development, Testing and Production with same cluster config and auto-scaling
- Managed Services:
  Replace self hosted DB-, Web- and Storage-Servers by managed cloud-services like PostgreSQL-as-a-Service and S3

Result:

- Increased availability and service stability
- Price drop by 10-30% thanks to more efficient ressource management and cheaper managed services



Summary: Your Key Takeaways

Key Lesssons

Wirth's Law is more relevant than ever.

In the cloud, pay-per-use means pay-per-waste.

We must measure, not guess.

Configuration is code.

More hardware is a band-aid, good architecture is the cure.

A Challenge For You

Three Questions for Your Projects

Do we measure?

Is our architecture helping us, or hurting us?

Are we efficient with our organisation's money and our planet‘s resources?

Thank You

Time for your questions

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