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# Internet of Things: Performance, Capacity, and Scalability Aspects

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**October 10, 2019**

## *About the Speaker*



- **Alexander Podelko**
- **Specializing in performance since 1997**
- **Currently Consulting Member of Technical Staff at Oracle (in Stamford, CT)**
- **Performance testing and optimization of Enterprise Performance Management (EPM) a.k.a. Hyperion products**
- **Board director at Computer Measurement Group (CMG) – non-profit organization of performance and capacity professionals**

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## *Agenda*

- IoT Challenge
- Benchmarking
- Performance Testing
- Modeling

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## Complexity of IoT Applications

- A global survey of 800 CIOs
- 74% of IT leaders are concerned that IoT performance problems could directly impact business operations
- 69% of CIOs predicted that IoT will become a major performance management burden as they struggle to overcome the escalating complexity of their enterprise cloud environments

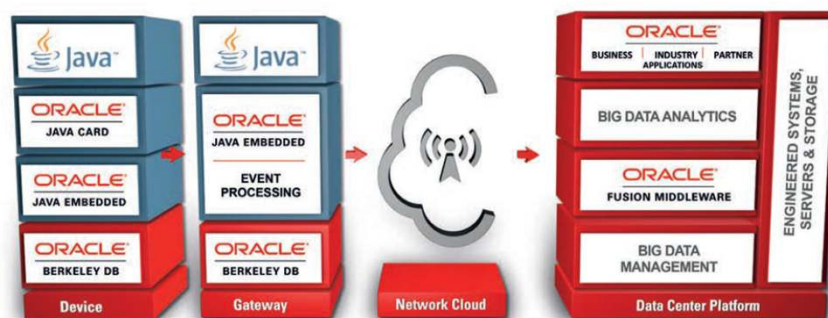
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## The Top Five Challenges

- IoT exponentially increases IT complexity
- IoT problems will have severe, real-world consequences
- Performance blind spots put IoT strategies at risk
- Digital experience expectations are expanding
- Visibility into web-scale IoT applications is limited

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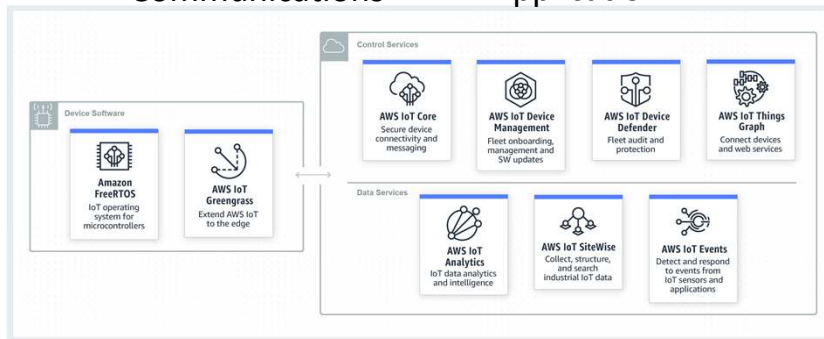
## Oracle's Internet of Things Platform



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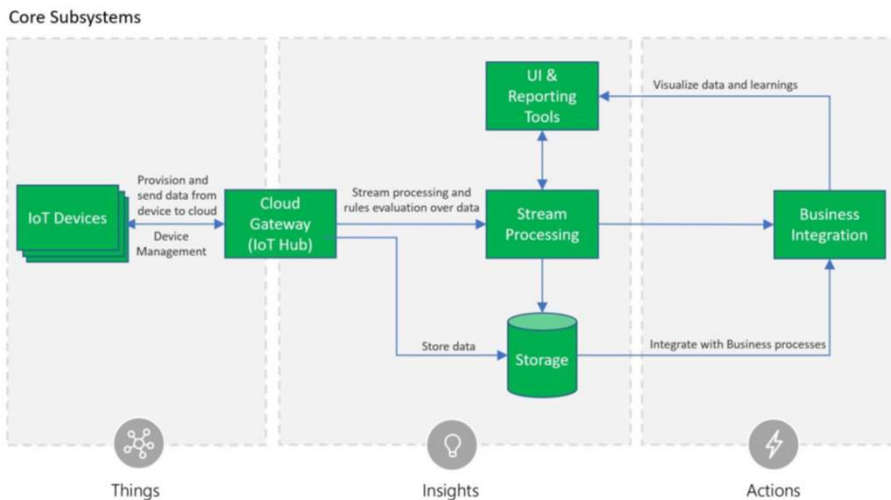
## AWS Well-Architected: IoT Lens

- Layers:
  - Edge
  - Provisioning
  - Communications
  - Ingestion
  - Analytics
  - Application



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## Azure IoT Reference Architecture



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## Custom Benchmarks

- “ClearBlade Shatters IoT Scalability Benchmarks by Leveraging Oracle Cloud Infrastructure High Performance Servers”
  - one million Edge Platform connections utilizing a single Oracle bare metal server instance [2017]



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## TPCx-IoT



- Transaction Processing Performance Council
- Industry's first benchmark which enables direct comparison of different software and hardware solutions for IoT gateways
- Data aggregation, real-time analytics and persistent storage
- 2017
- <http://tpc.org/tpcx-iot>

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## EEMBC IoT Mark

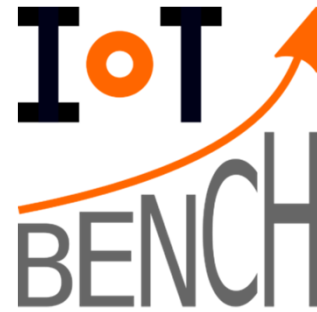
EMBEDDED MICROPROCESSOR  
BENCHMARK CONSORTIUM

- Objective, standardized benchmarking framework for measuring the energy efficiency of IoT edge nodes
- <https://eembc.org/iotmark>

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## IoT Benchmarks Initiative

- Low-power wireless networking community worldwide
- Building testbeds and tools to enable realistic experimental validation
- <https://iotbench.ethz.ch>



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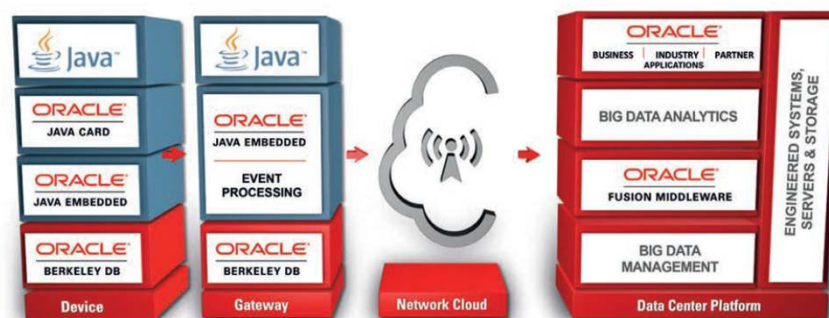
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## Performance Testing Challenges

- Protocols
  - MQ Telemetry Transport (MQTT)
  - Constrained Application Protocol (CoAP)
  - AMQP, XMPP, DDS, REST APIs over HTTP, etc.
- Network Emulation
- Monitoring
- Service Virtualization

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## Oracle's Internet of Things Platform



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## Load Testing Tools

- Different level of support [list by Scott Moore]
  - Iotify.io
  - Mosquitto
  - Malaria
  - Copper
  - MQTTBox
  - MQTT JMeter
  - Gatling-MQTT
  - NeoLoad
  - LoadUI NG
  - StormRunner
  - LoadRunner
  - Locust / Paho
  - Check-MQTT
  - MQTT-stresser
  - MQTT-bot
  - MQTT-PWN

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## Performance Modeling

- Systems become too complex
- Modeling as an answer
  - Provides a large performance picture
  - Integrates all diverse data
  - Validates results
  - Complements testing [what-if scenarios]

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## Principles

- "All models are wrong, but some are useful"
  - by George Box
- "Everything should be made as simple as possible, but not simpler"
  - by Albert Einstein

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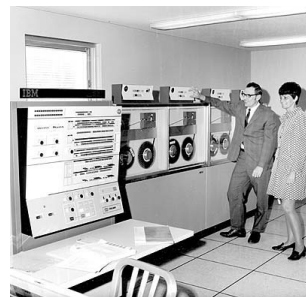
## “Black Box” vs. “White Box”

- “Black box”, production view
  - Wider used / supported
  - System as is, no component changes
  - Data extrapolation: time series forecasting, trending, ML, etc.
- “White box”, architecture view
  - Almost disappeared
  - What-if on component level
  - Should be most beneficial for IoT

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## 1966: Instrumentation

- 1966 – SMF (System Management Facilities) released as part of OS/360
  - Still in use
- *Big Data ?*
- *Deep Diagnostics ?*
- *IT Operations Analytics ?*
- *Observability ?*



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## 1977: Performance Analysis Tool

- 1977 – BEST/1 was released by BGS Systems, capacity and performance management tool
  - the first commercial package for computer performance analysis to be based on analytic models.

– Acquired by BMC Software in 1998

```
Work with BEST/1 Model
Performance data . . . : BESTDATA (Q930400309)
Model/Text . . . . . : BEST1MODEL

Select one of the following:

1. Work with workloads
2. Specify objectives and active jobs

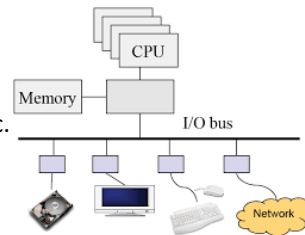
5. Analyze current model
6. Analyze current model and give recommendations
7. Specify workload growth and analyze model

10. Configuration menu
11. Work with results

More ...
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```

## Resources

- CPU, I/O, memory, and network
  - And software objects
    - Connection and thread pools, caches, etc.
- Resource Utilization
  - Related to a particular configuration
  - Often generic policies like CPU below 70%
- Relative values (in %) are not useful if configuration is not given
  - Commercial Off-the-Shelf (COTS) software
  - Virtual environments

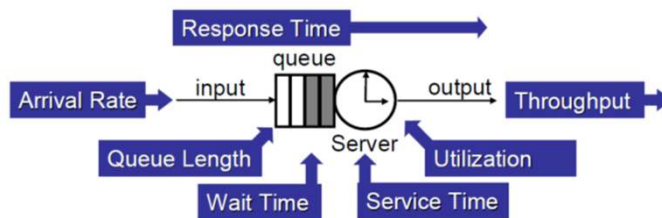


## Resources: Absolute Values

- Absolute values
  - # of instructions, I/O per transaction
    - Seen mainly in modeling
  - MIPS in mainframe world
  - IOPS, MiB/s
- Importance increases in cloud
  - VMware: CPU usage in MHz
  - Amazon: EC2 Compute Units (ECU)
  - Oracle: OCPU

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## Queueing Theory



- M/M/1
  - Distribution of arrival/service /number of servers
  - Kendall's notation
  - Analytical models / Simulation


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## Tools - Analytical

- BEST/1 [acquired by BMC, TrueSight Capacity Optimization now (??)]
- TeamQuest [acquired by HelpSystems]
- Metron Athene [acquired by SyncSort]
  
- PDQ - open source by Dr. Neil Gunther
- SPE·ED – by Dr. Connie U. Smith
- JMT – Java Modelling Tools

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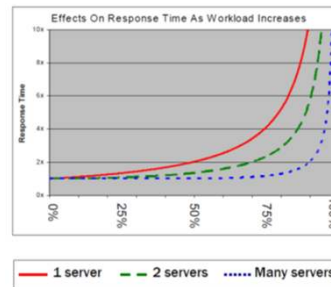
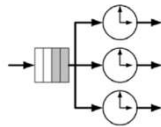
## Tools - Simulation

- HyPerformix [acquired by CA  ]]
- Palladio
- QPME (Queueing Petri net Modeling Environment)
  
- Not IT-specific / Discrete Event Simulation
  - MathWorks SimEvents
  - OMNeT++
  - Many other commercial and open source tools

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## Multiple Servers

M/M/m Queue



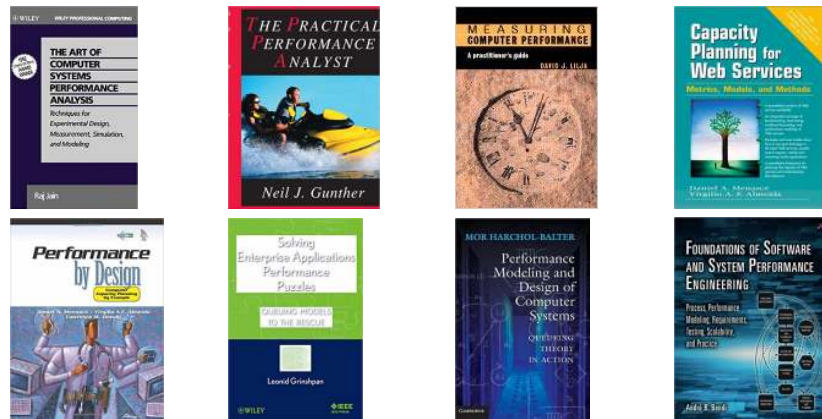
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## Decline of Modeling Tools

- No “white box” modeling tool in active development [according to my knowledge]
- Existing tools doesn't keep up with modern trends
  - Scaling out
    - Lower need for queueing models
  - Drastic increase in sophistication
    - Need to model very complex architectures
    - Configuration discovery
    - Large variations in systems, no generic approach

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## Fundamental Books



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## More Flexible Approach

### Introductory Books



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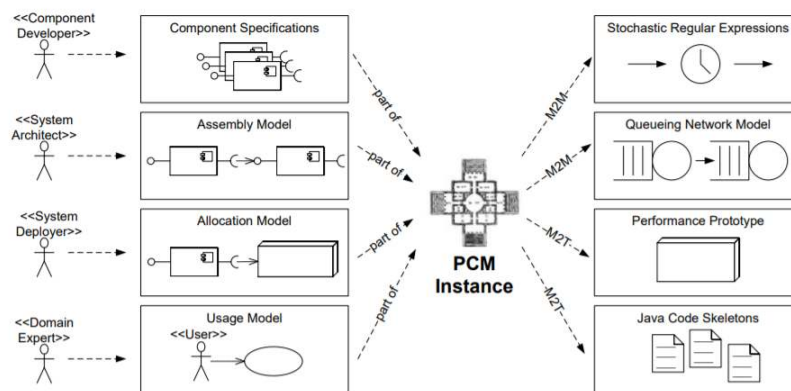


## HyPerformix Approach

- Three types of data (Type 1, 2, and 3)
- **T1** Single Business Function Trace
  - tier-to-tier workflow of each of the application’s business functions
- **T2** Single Business Function Load Test
  - system resources required to process each business function on each server
- **T3** Load Test
  - typical load test with a mixed workload
  - model validation

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## Palladio Approach



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## Summary

- Performance is a major issue for IoT
- IoT consists of multiple systems from the performance point of view
  - So benchmarking and testing are usually covering specific parts
- Performance modeling should help
  - Rather empty field for “white box” modeling

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## *Questions?*

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