An Infrastructure for Automating Large-scale Performance Studies (Elba under-the-hood)

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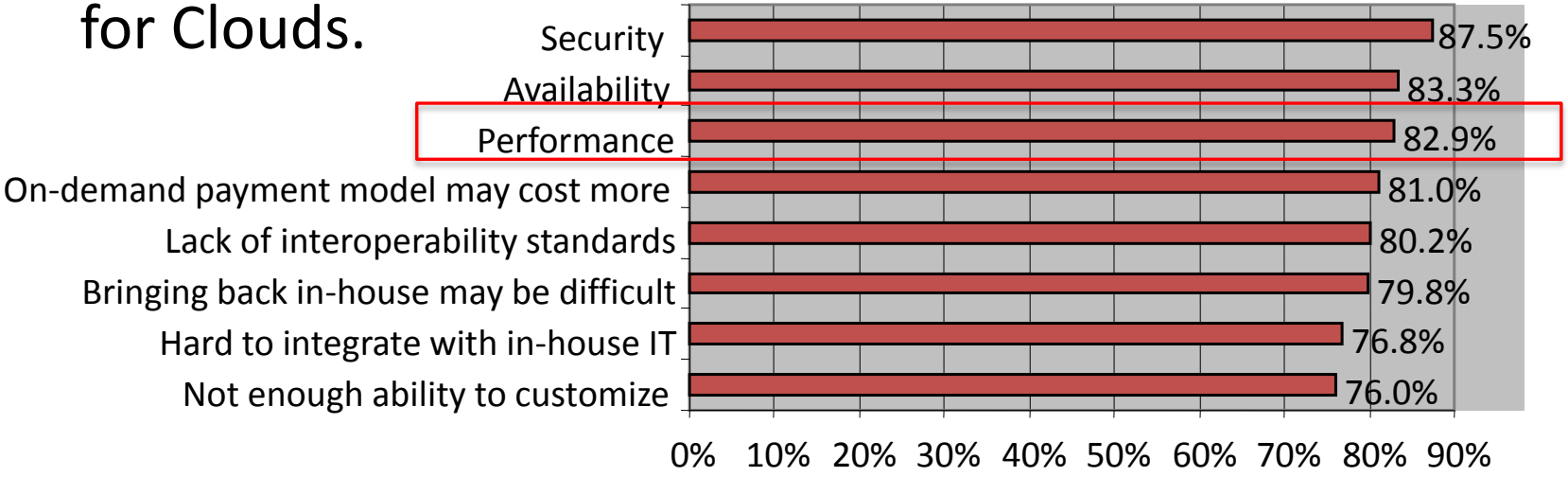
Many PhD, MS, Undergrad students

Many company collaborators and support from several companies, particularly from Fujitsu and Intel.

Importance of Predictable Performance

- Extra delay of just 100ms could result in roughly 1% loss in sales. amazon.com
- Additional delay of just 500ms could reduce revenues by 20%. Google
- IDC reported performance to be top 3 user considerations for Clouds.



Cloud Computing & Performance

- Cloud is a ***black-box*** for many users.
- Application providers face non-trivial performance challenges.
- One of the most effective ways to understand a cloud is to measure it:
  - Run measurement studies and collect data
  - Maybe it's the only way

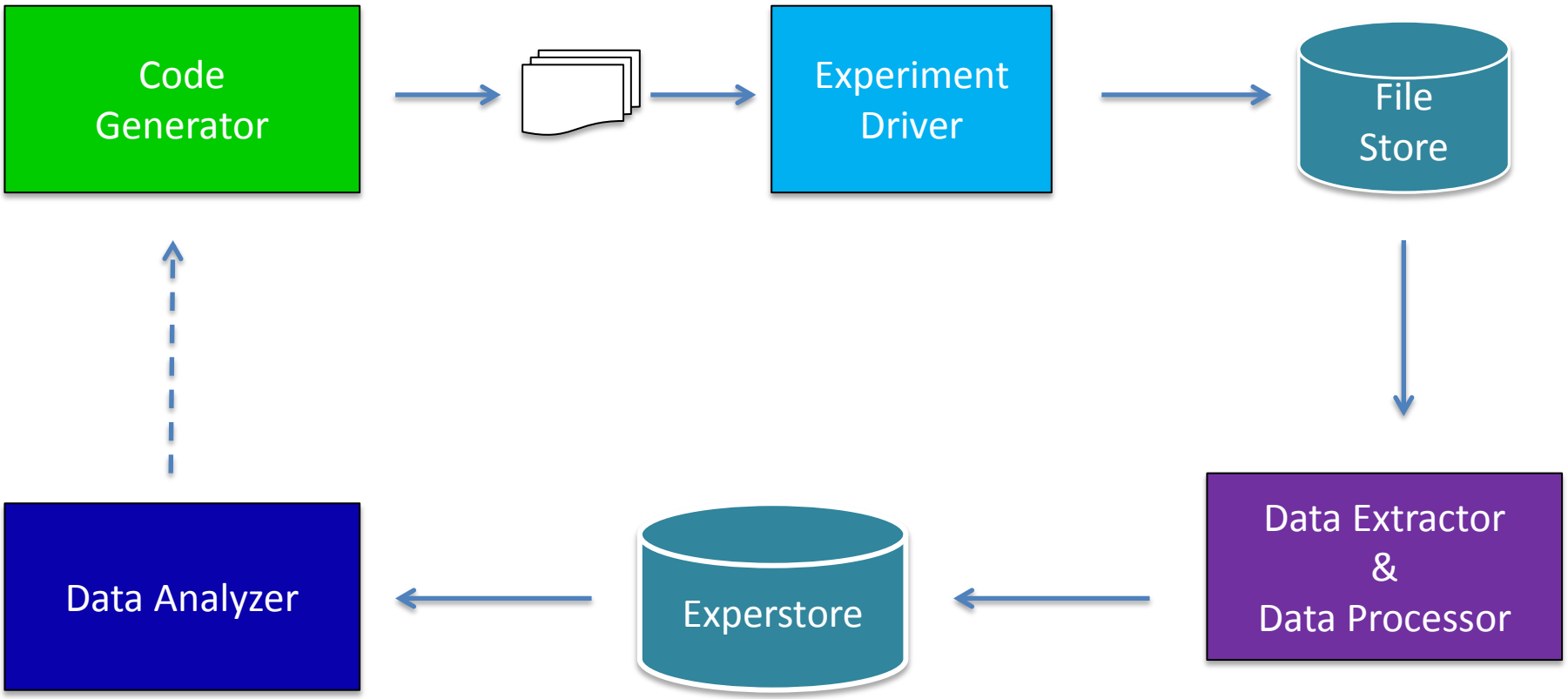
Large-scale Experimental Measurements

- **Goal**: Use large-scale experimental data as “real” (predictive) models for performance and scalability constraints;
- **Challenges:**
  - Deployment complexity due to configuration dependencies
  - Large state space: Many configuration options
  - Huge amount of data: >1GB/experiment, semi-structured data

Automating Large-scale Experiments

- **Create**
  - Prepare the platform, deploy and configure application.
- **Manage**
  - Start application, execute workload, data collection.
- **Analyze**
  - Data analysis (visualization) and building hypothesis.

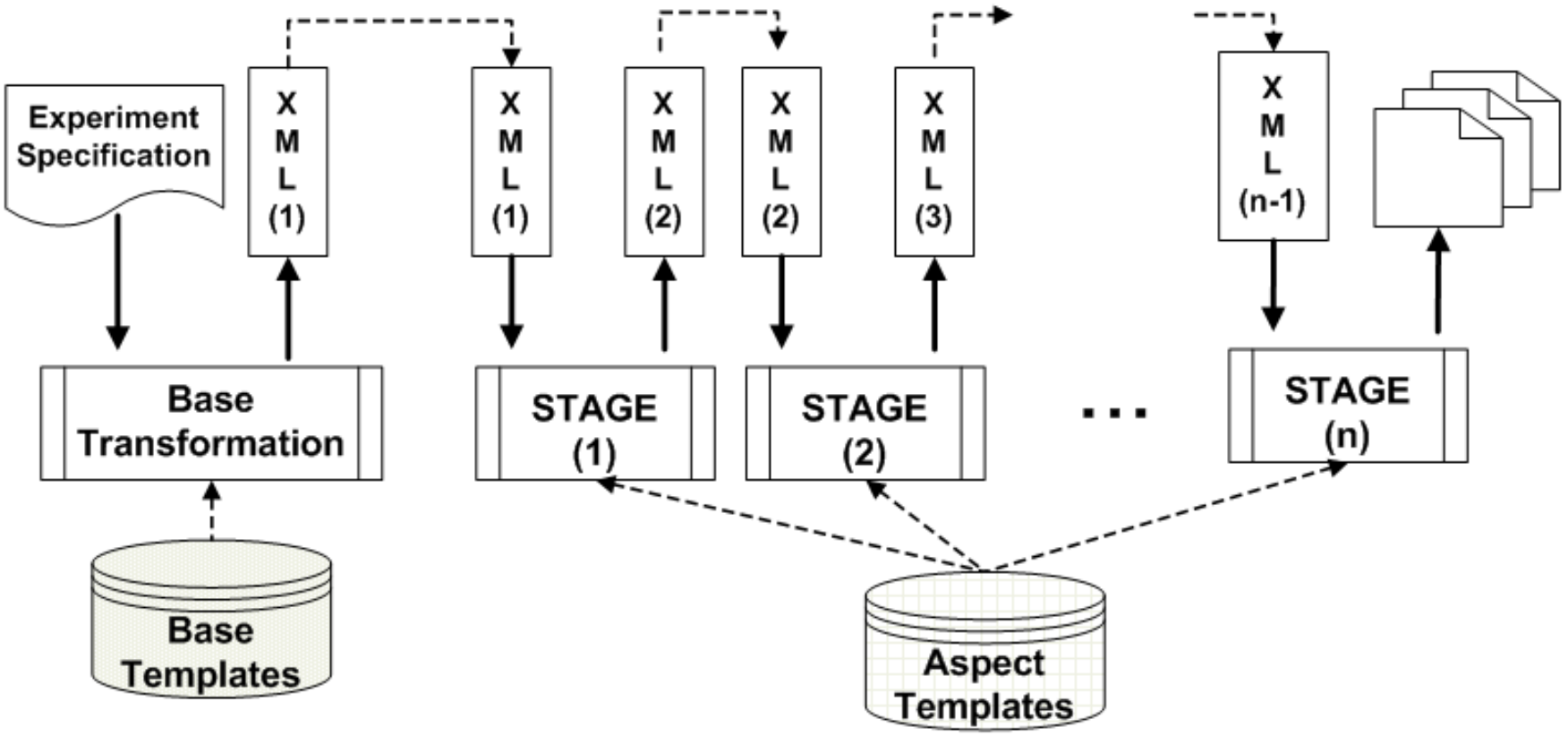
Performance Measurement Workflow



Expertus – Code Generator

- **Idea**: Generate scripts to automatically create, manage and analyze the experiments from user-friendly specification files.
- Key Challenges:
  - **From abstract mapping to concrete scripts**
  - **Heterogeneity of hardware and software components**
  - **Flexible customization needed in experiments**
- Solution platform: XML + XSLT + AOP

Code Generation Pipeline



Template Types

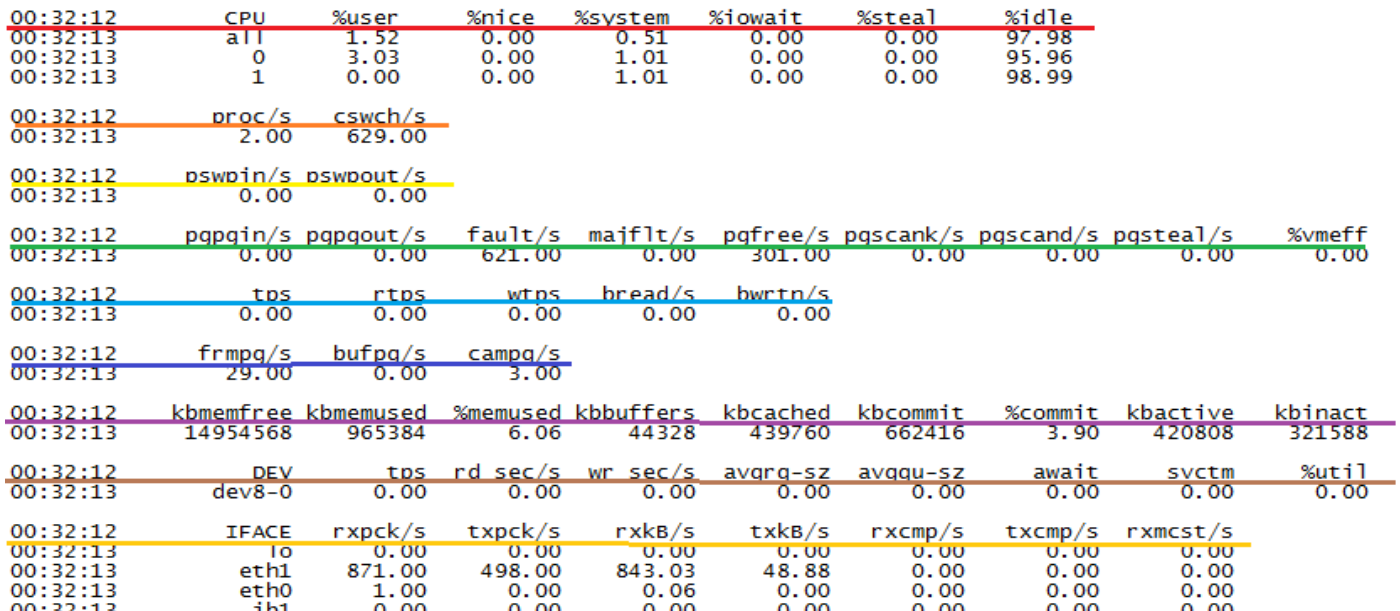
- Base Templates
  - To generate OS, cloud, and user independent resources.
  - A template for each possible action (e.g., deploy-tomcat) and resource (e.g., httpd.conf).
  - Created by identifying output variances (each of which becomes an aspect).
- Aspect Templates
  - Customize to meet application, cloud, and user needs.
  - Can contain one or more advices.
  - Nested pointcuts – an advice can add zero or more pointcuts.

Expertract - Automated Data Extractor

- Performance logs from various monitors, semi-structured
  - Potentially, a custom data parser for each experiment
- Log file format with many variations
  - Monitoring tools (e.g., dstat, sar, o-profiler …) and parameter settings
- ETL (Extract, Transform, Load) tools insufficient by themselves
  - Need to figure out the actual log layout

Most Common File Formats

- One header
- Multiple headers with sequentially corresponding data
- Multiple headers with non-sequential corresponding data
- Multiple headers appear randomly in the file and data is entirely non-sequential

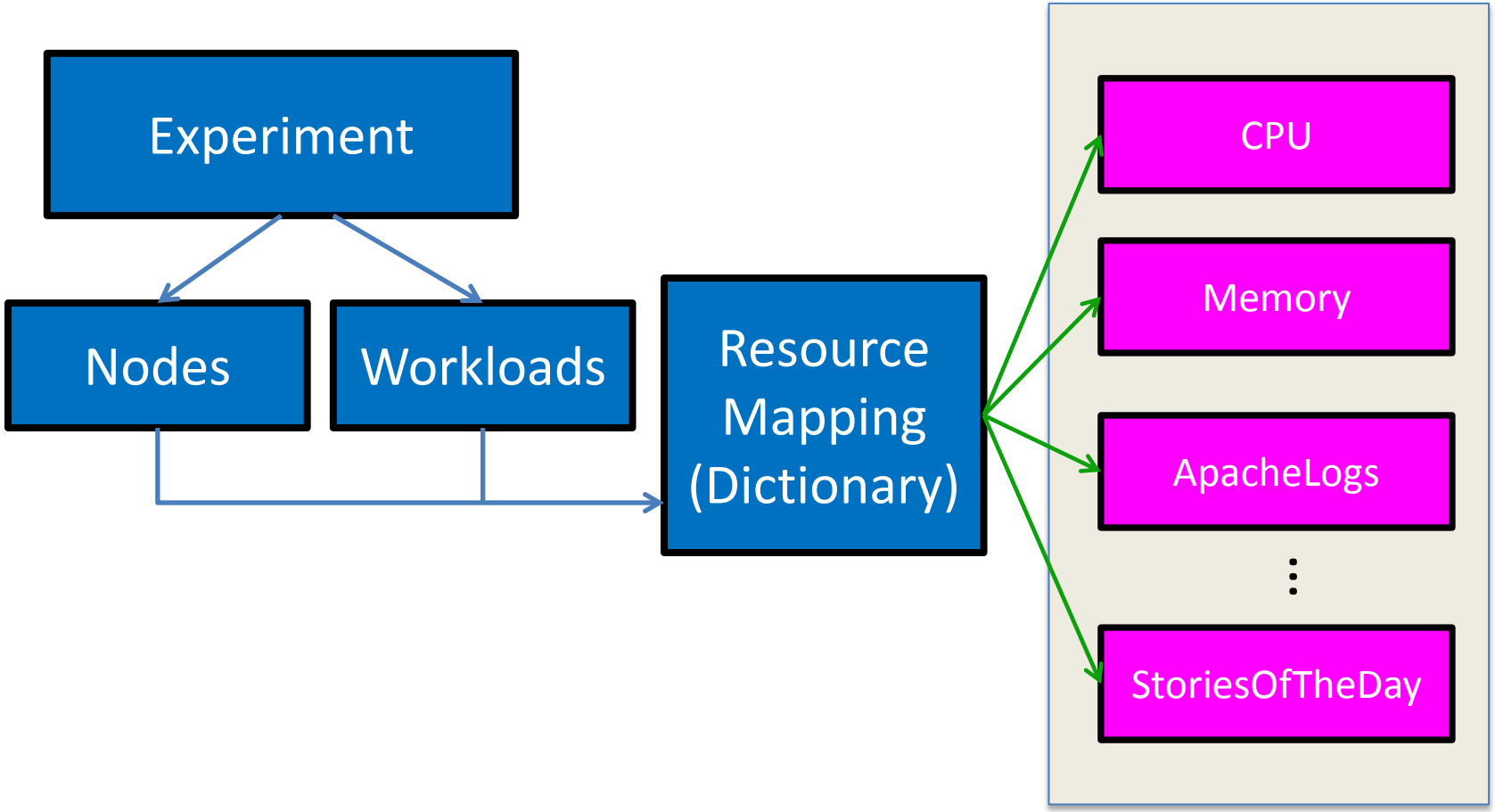


```
00:32:12        CPU     %user     %nice   %system   %iowait    %steal     %idle
00:32:13        all      1.52      0.00      0.51      0.00      0.00     97.98
00:32:13          0      3.03      0.00      1.01      0.00      0.00     95.96
00:32:13          1      0.00      0.00      1.01      0.00      0.00     98.99

00:32:12       proc/s   cswch/s
00:32:13         2.00    629.00

00:32:12     pswpin/s pswpout/s
00:32:13         0.00      0.00

00:32:12     pgpgin/s pgpgout/s   fault/s  majflt/s  pgfree/s pgscank/s pgscand/s pgsteal/s    %vmeff
00:32:13         0.00      0.00    621.00      0.00    301.00      0.00      0.00      0.00      0.00

00:32:12          tps      rtps      wtps   bread/s   bwrtn/s
00:32:13         0.00      0.00      0.00      0.00      0.00

00:32:12      frmpg/s   bufpg/s   campg/s
00:32:13        29.00      0.00      3.00

00:32:12    kbmemfree kbmemused  %memused kbbuffers  kbcached  kbcommit   %commit  kbactive   kbinact
00:32:13     14954568    965384      6.06     44328    439760    662416      3.90    420808    321588

00:32:12          DEV       tps  rd_sec/s  wr_sec/s  avgrq-sz  avgqu-sz     await     svctm     %util
00:32:13         dev8-0      0.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00

00:32:12        IFACE   rxpck/s   txpck/s    rxkB/s    txkB/s   rxcmp/s   txcmp/s  rxmcst/s
00:32:13           lo      0.00      0.00      0.00      0.00      0.00      0.00      0.00
00:32:13         eth1    871.00    498.00    843.03     48.88      0.00      0.00      0.00
00:32:13         eth0      1.00      0.00      0.06      0.00      0.00      0.00      0.00
00:32:13          ib1      0.00      0.00      0.00      0.00      0.00      0.00      0.00
```

Experstore - A Flexible Data Warehouse

- Tables are created *on-the-fly* based on the data.
- Why not static tables? (global schema too big)
  - Several monitoring programs
  - Many different parameter settings: e.g., 2 core vs. 4 cores
- Why not column based tables?
  - Would be too many tables (over 20000 tables per experiment).
  - (# Workload) * (# Nodes) * (# Resources).
- Our solution – A hybrid approach:
  - Create small tables to store related data, for example a table to store CPU data that consists of user, sys, idle etc…

Static and Dynamic Tables



Data to Schema Mapping

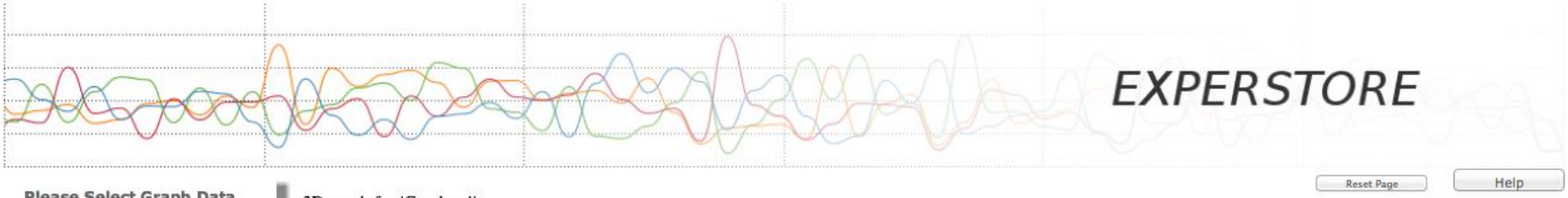
- Mapping performance data to a table (to-be-created) in the data warehouse.
  - Which columns (row) to read ?.
  - How to format (e.g., datetime) ?.
  - What to include/exclude ?.
  - Which parser to use ?.
- Specifying resources for a given node.
  - e.g., CPU1, CPU2, network, IO etc …
- Mapping result directories to workloads.
  - e.g., “2009-11-29@11-25-40”→ 1000-RO
- Mapping log files to a node/resources.
  - e.g., mod_jk.log → request processing time at Apache.

Data Analysis - Web Portal

- Aid the analysis of large amount of data.
- Identify patterns, trends and relations.
- Control the way in which data is represented.
- Data from seemingly unrelated sources could be easily compared against each other.

Web Portal-2D

Web Portal-3D



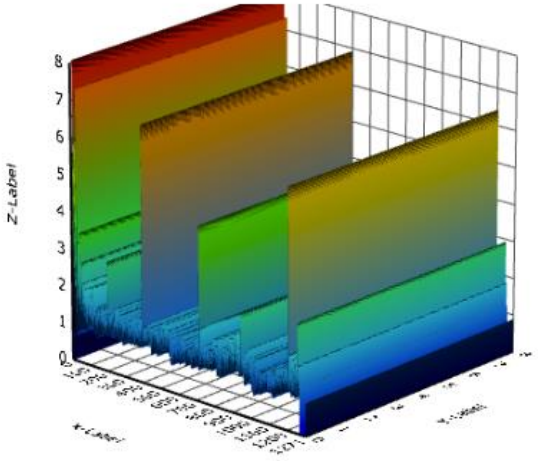
Please Select Graph Data

Select Graph:	Graph - 4
Experiment Name:	rubbos-1-2-:
Iteration:	1
Node Name:	Tomcat2
Resource:	CPU0
Series:	user
Range:	1 to 1271
Step Size:	step
Type of Graph:	Line
Advanced Graph:	3-D Graph
Graph Title:	Title
X-Axis Label:	X-Label
Y-Axis Label:	Y-Label
Z-Axis Label:	Z-Label
Function for plot:	x

Please Select Graph Operation

Operations: --Select--

3D graph for 'Graph - 4'
Z: 1:1
Y: 1:10
X: 1:1

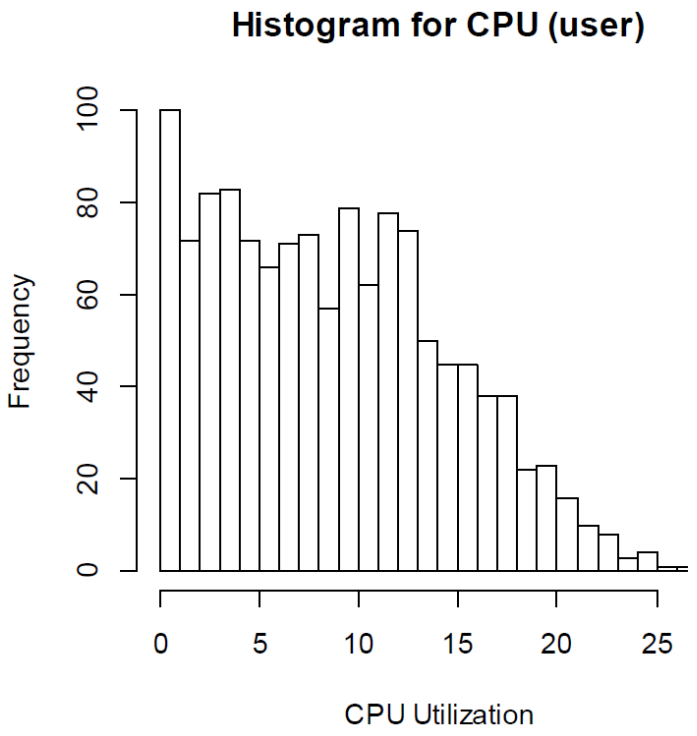


Support for *R* Framework

Generated Script

```
drv <- JDBC("com.mysql.jdbc.Driver",
      "C:/mysql/mysql-connector-java-5.1.7-
       bin.jar",
      identifier.quote="`")

conn <- dbConnect(drv,

       "jdbc:mysql://elbafs.cc.gatech.edu:3313/elba
       ",
      "elba", "elba")

d   = dbGetQuery(conn, "select user from
     TAB1333977005752002l9B_CPU0
     where dictionaryid='334'")

hist(d$user, breaks=20, col="white",
    xlab="CPU Utilization",
    main="Histogram for CPU (user)")
```

Generated Graph



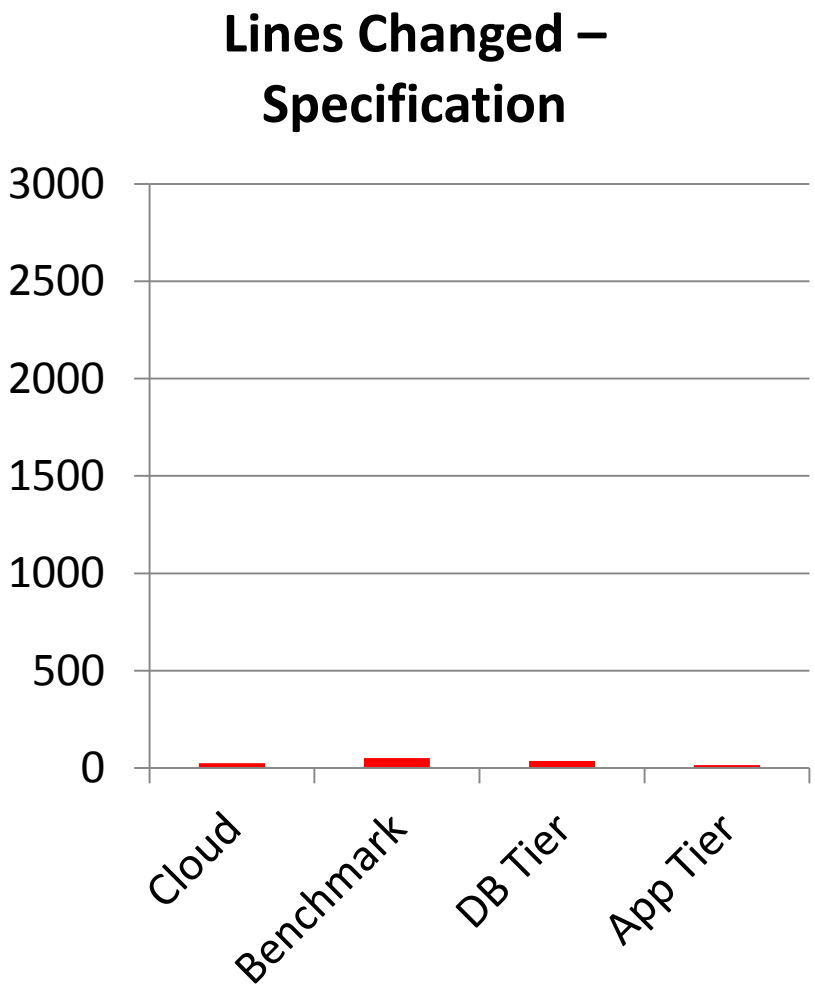
Wide Applicability

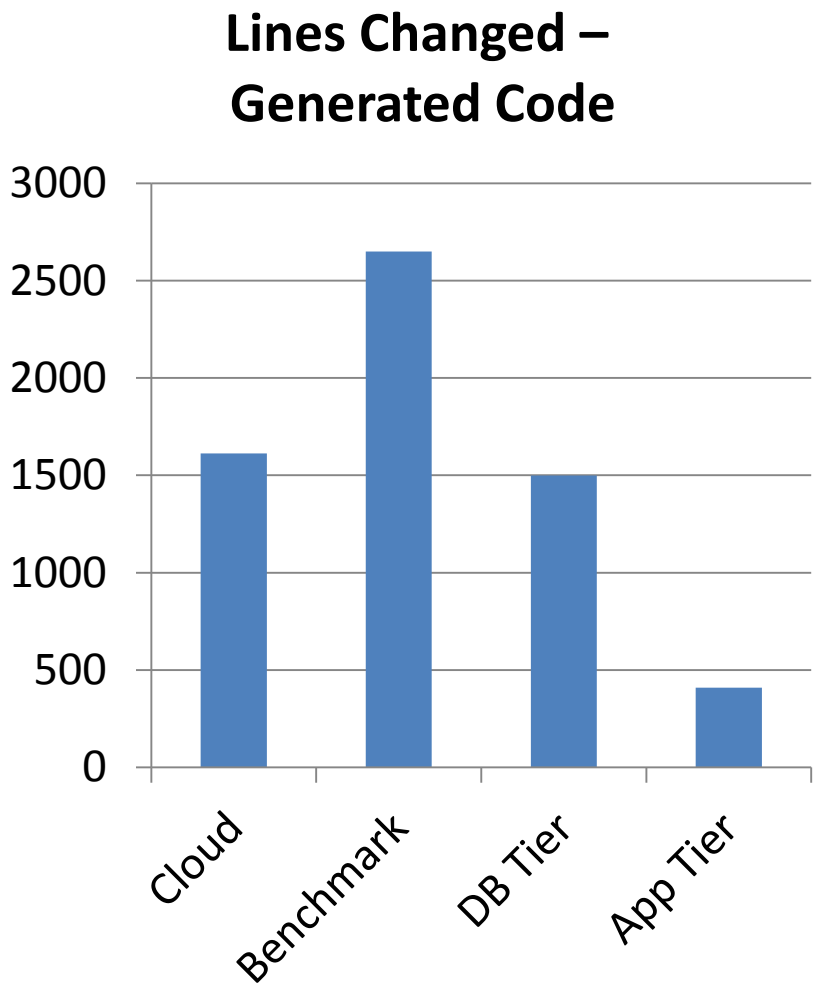
- Over 500 different hardware configurations.
- Over 10,000 software configurations.
- Over 100,000 nodes.
- Many clouds (e.g., Emulab, EC2, OpenCirrus, Georgia Tech cluster, and Wipro).
- Many representative applications (e.g., RUBBoS, RUBiS, CloudStone, and over 10 OLTP benchmarks).

High-Level Summary

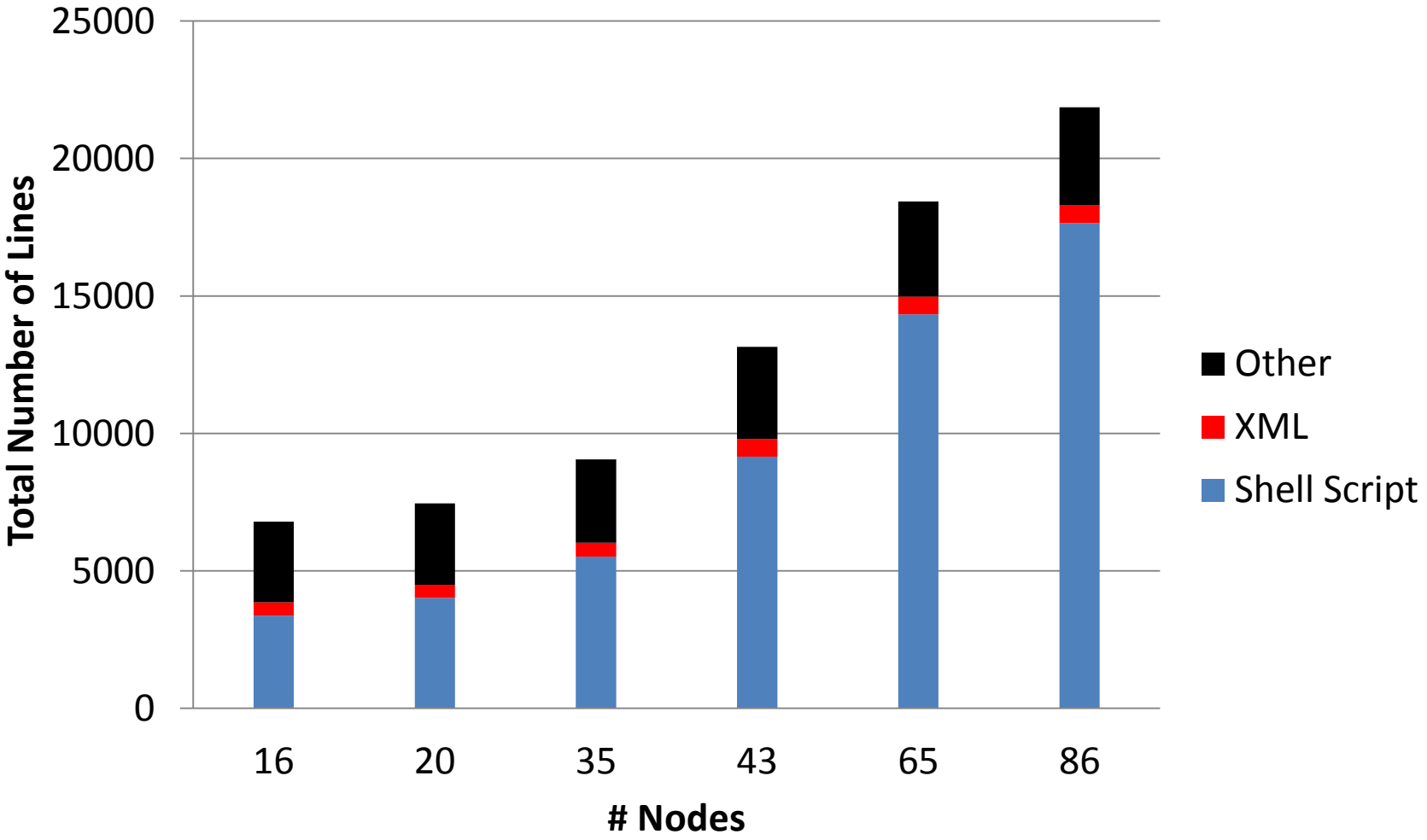
Type	Emulab	EC2	OpenCirrus	Elba	Wipro
Experiments	9215	1436	480	3567	120
Nodes	102687	25848	4987	9865	430
Configurations	392	86	28	163	8

Specification Changes vs. Changes in Generated Code





Number of Nodes vs. Generated Code



2013 Elba Publications

- **Q. Wang, Y. Kanemasa, et al**, Impact of DVFS on n-Tier Application Performance. In *TRIOS 2013*
- **D. Jayasinghe, et al**. An Infrastructure for Automating Large-scale Performance Studies and Data Processing. In IEEE BigData 2013
- **Q. Wang, Y. Kanemasa, et al.** "Detecting Transient Bottlenecks in n-Tier Applications through Fine-Grained Analysis", In *ICDCS 2013.*
- **Q. Wang, Y. Kanemasa, et al.** "An Experimental Study of Rapidly Alternating Bottlenecks in n-Tier Applications", In *IEEE Cloud 2013*
- **D. Jayasinghe, Fabio Oliveira, et al.** "AESON: A Model-Driven and Fault Tolerant Composite Deployment Runtime for Clouds", In *SCC 2013*
- **Junhee Park, Y. Kanemasa, et al.** "Variations in Performance Measurements of Multi-Core Processors: A Study ", In *SCC 2013*
- **Jack Li, et al.** "Performance Overhead Among Three Hypervisors: An Experimental Study ", In *IEEE BigData Congress 2013*
- **Y. Kanemasa, Q. Wang, et al.** "Revisiting Performance Interference among Consolidated n-Tier Applications", In *SCC 2013*

Ongoing Work

- Extending the data parser to support additional data formats.
- Extending the data warehouse to use No-SQL databases.
- Extending the visualization tool to support more customizable graphing capabilities.

Conclusions

- Help researchers efficiently creating, storing and analyzing performance measurement data.
- Open new opportunities and enable large-scale experiments above and beyond manual application testing.