

Predictive analytics for IT and service management

Daniel Roscigno,
IBM Tivoli Operations Architect



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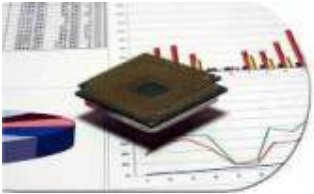
Performance is based on measurements and projections using standard IBM benchmarks in a controlled environment. The actual throughput or performance that any user will experience will vary depending upon many factors, including considerations such as the amount of multiprogramming in the user's job stream, the I/O configuration, the storage configuration, and the workload processed. Therefore, no assurance can be given that an individual user will achieve results similar to those stated here.

How can we avoid business disruption? And decrease operational costs?



Operational costs of systems and networking are rising
Maintenance costs: \$8 spent for every \$1 spent on new infrastructure*

* Source: IDC 2007



There's an explosion in volume of data and information
Virtualization and cloud bring increased dynamicity and change
Unpredictable workload characteristics

Challenge: Improve the assurance of physical and virtual environments across applications, systems, networks and storage.

Analytics for Service Assurance approach: Add advanced analytics over operational data to detect problems before they become service affecting.

Move from “reactive” management to fixing things before they break.

Predictive analytics!

“I’d like 30 minutes warning to know when my user experience is going to deteriorate”

“After we fix the problem, then we set another threshold”

“What are realistic baselines? How can I reduce false alerts?”

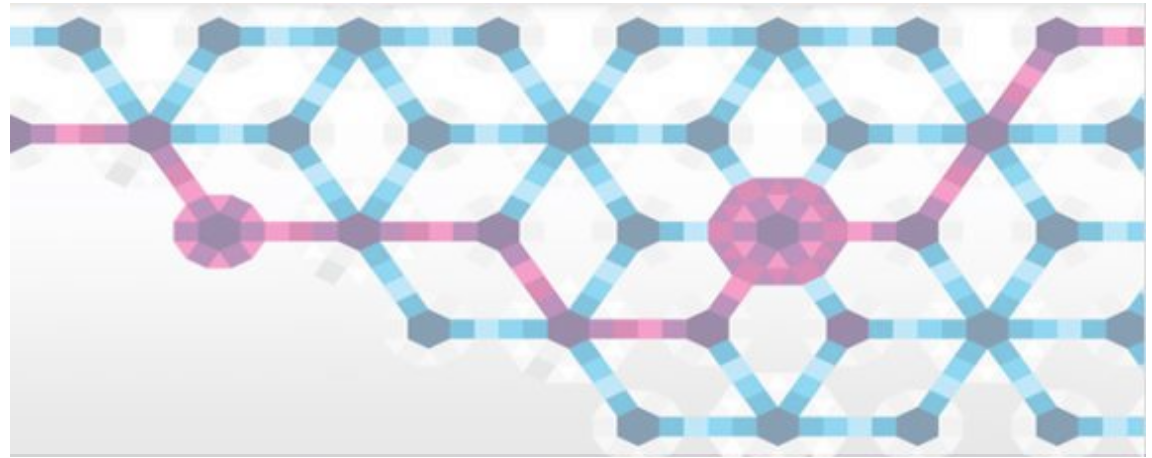
Analytics...

why is this happening

what if these trends continue

what will happen next
(that is, **predict**)

what is the best that can happen
(that is, **optimize**)



IBM is driving the future of integrated analytics through acquisitions and our strategic partnerships:

Trigo

iphrase
SRD

Ascential

dwl
LAS

UNICORN

FILENET
DataMirror

COGNOS

ILLOG
Changing the rules of business™

solid.

Core metrics
An IBM Company

princeton
softech

EXEROS

unica

SPSS

NETEZZA

i2

A

IBM Research Business Analytics and Optimization

- Over 200 researchers with expertise in data analytics, operations research, mathematics, and industry applications of analytics
- Hold 300 patents and have an additional 450 pending on analytics and business applications
- Support IBM's "fact-based" management and processes in sales, supply chain, and services.
- Participate with IBM consultants in cutting-edge client projects
- Add differentiation through data analytics to outsourced accounts
- Provide new algorithms to IBM SW products
- Lead in the global scientific community
 - Over 250 publications in leading conferences and journals in recent years
 - Fellows at several leading professional societies
 - Successive wins at KDD Cup and INFORMS Data Mining Competitions (premier competitions)
 - Leaders in Optimization Open Source
 - Major INFORMS prizes and awards
 - Adjunct faculty at leading universities

Improved profitability through analysis of customer networks for a major telecom customer by providing better customer targeting

sktische Funktion $f: \Omega \rightarrow \mathbb{R}$ gibt:
 $f = \sum_{k=1}^{\infty} \|f_k\|_{L^2}^2$

Deployed operational planning and scheduling to run steel plants at several leading Asian steel manufacturers – improved productivity

$\langle f, g \rangle_{L^2} = \int_{\Omega} f(x)g(x) dx$

Design optimal maintenance plan for a set of interconnected offshore oil platforms - improve availability of oil platforms

$\frac{1}{s} \frac{\partial u}{\partial s} + \frac{1}{s^2} \frac{\partial^2 u}{\partial \varphi^2} + \frac{\partial^2 u}{\partial z^2} = \frac{1}{c^2} \frac{\partial^2 u}{\partial t^2}$

Analytics-Driven Solutions for Increased IBM sales force productivity – increased revenue and profitability

$J_k^2(j_k, u, x) dx = \frac{1}{2} J_k'(j_k, u) = \frac{1}{2} J_{k+1}(j_k, u)^2$

Improved wafer yield at the IBM 300mm semiconductor plant deploying data mining and machine learning*

$J_0(0) = 1 \quad J_n(0) = 0 \text{ mit } n > 0.$

Creation of state-of-the-art error correction code technology that is used in main memory systems of IBM's computers

$J_{-k}(x) = \sum_{n=0}^{\infty} \frac{(-1)^{n+k}}{(n+k)!} \left(\frac{x}{2}\right)^{2n+k}$

Centralized control and real-time visibility of the end-to-end supply chain for IBM supply chain – reducing inventory

$N_k(x) = \lim_{\lambda \rightarrow \infty} \frac{\cos(\lambda\pi) J_\lambda(x) - J_{-\lambda}(x)}{\sin(\lambda\pi)}$

Provide analysis of operational risk loss data for 36 leading banks from 13 countries - cross enterprise secure and anonymous data sharing

$N_k(x) = \infty$ Neumann-Fkt.

IBM Business Analytics

Software that Addresses Key Customer Needs

Cognos.
software

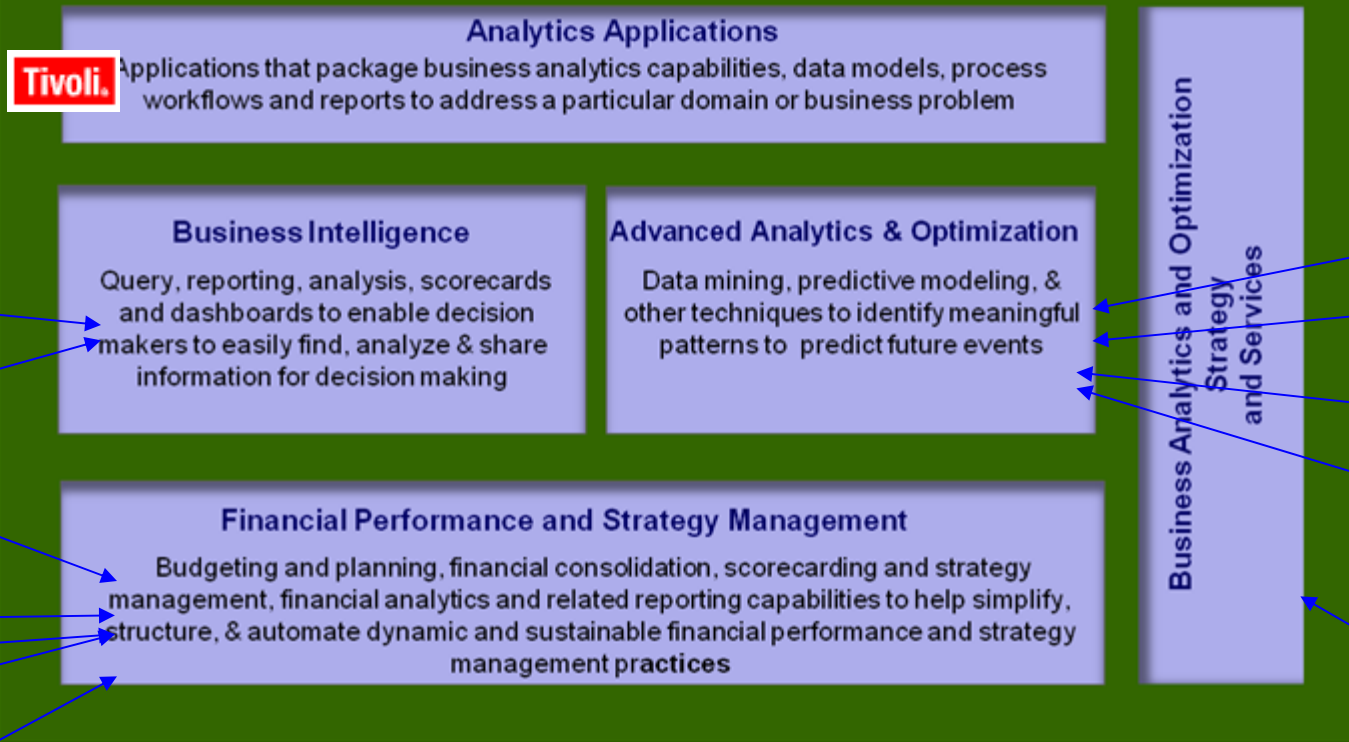
InfoSphere[™]
software

Tivoli. software

SPSS
AN IBM COMPANY

ILOG

Key Customer Needs in Business Analytics



Tivoli.

Cognos.
software

CORE METRICS

Initiate

DB2

Guardium

optim

FILENET
AN IBM COMPANY

InfoSphere
software

SPSS
AN IBM COMPANY

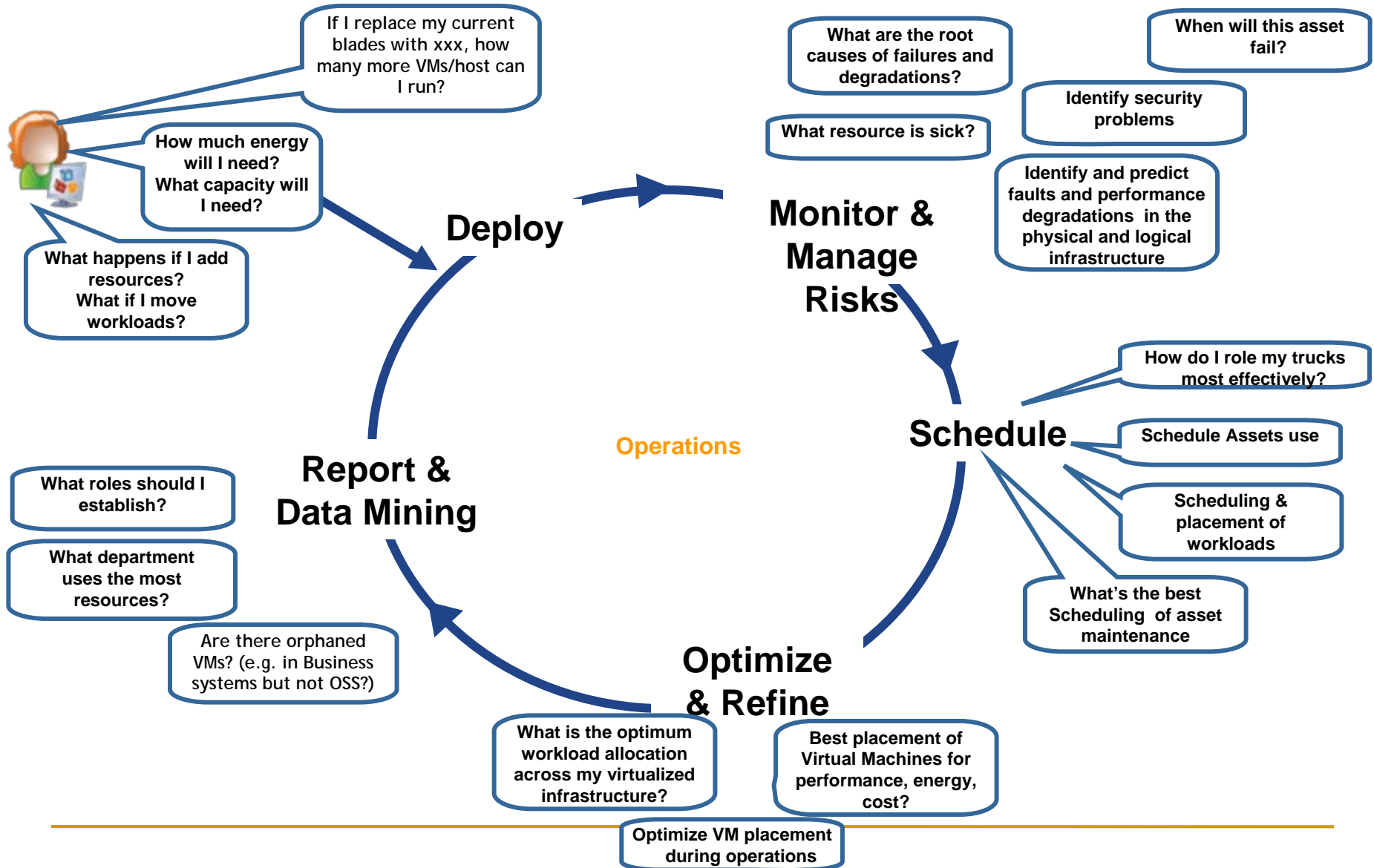
NETEZZA

Lombardi
AN IBM COMPANY

CLARITY systems

Breadth of operational analytics for ISM

Tivoli software



Analytics in IBM Tivoli Service Management Today

The screenshot displays the IBM Tivoli Service Management interface, divided into three main sections:

- Service Navigator (Left):** A hierarchical tree view of services and their components across various locations (Chicago, HongKong, London, New York, Tokyo). A table below the tree provides performance metrics for each component.
- Service Canvas (Right):** A graphical view of the 'ET_ExchangeTrading' service, showing its internal structure and associated components like ET_Login, ET_Convert, ET_Transfer, ET_Login, and ET_Cancel.
- Service Details (Bottom Right):** A table showing service attributes and their values, such as OverallAttribute, PctWorseThanAvgRes, and ResponseTime.

Five callout boxes highlight specific analytical capabilities:

- Statistical analysis:** Points to the performance metrics table in the Service Navigator.
- State to Service Analytics:** Points to the state indicators (green, yellow, red) in the Service Navigator tree.
- Event correlation to Services analytics:** Points to the Service Canvas view.
- KPI calculation & correlation to service definition:** Points to the Service Canvas view.
- Service to Infrastructure Correlation:** Points to the Service Navigator tree.
- Event correlation & enrichment analytics:** Points to the Service Details table.

Service	State	Infrastructure State	% Throughput vs. Baseline	ResponseTime	Historical Baseline	Total Tickets
ExchangeTrading	Green	Green	64%			
Chicago	Yellow	Yellow	56%			
ET_Convert	Red	Red	68%			
ET_Login	Red	Red	47%			
ET_Transfer	Yellow	Yellow	79%			
HongKong	Green	Green	88%	635	540	9
OnlineBanking	Green	Green	85%	455	408	0
London	Green	Green	89%	22	27	0
ET_Convert	Green	Green	124%	302	250	0
ET_Login	Green	Green	100%	131	131	0
ET_Transfer	Green	Green	82%	816	672	0
StockTrader	Green	Green	115%	131	151	0
ET_Cancel	Red	Red	69%	292	202	0
ET_GetQuote	Yellow	Yellow	81%	393	319	0
ET_Transfer	Green	Green	0%	0	0	0
cluster34	Green	Green	96%	635	612	0
ET_ExecuteBuyOrder	Red	Red	104%	643	671	0
ET_ExecuteSellOrder	Red	Red	47%	146	69	12
ET_GetQuote	Green	Green	138%	135	187	0
traderouter (server1)	Green	Green	79%	151	120	0
caesarS1:server1 (WebSphe)	Green	Green	147%	91	134	0
ET_Login	Green	Green	150%	12	18	8
New York	Green	Green	96%	565	542	31
ET_CancelOrder	Green	Green	95%	159	152	7
ET_ChangeOrder	Green	Green		175	0	0
ET_ExecuteBuyOrder	Yellow	Yellow		114	0	0
ET_ExecuteSellOrder	Green	Green		7	0	0
ET_GetQuote	Green	Green		19	5	0
ET_Login	Green	Green		75	16	0
Tokyo	Yellow	Yellow	125%	622	31	0
ET_CancelOrder	Red	Red		156	7	0
ET_ChangeOrder	Red	Red		144	4	0
ET_ExecuteBuyOrder	Green	Green		112	140	6
ET_ExecuteSellOrder	Red	Red	61%	38	23	0
ET_GetQuote	Yellow	Yellow	78%	74	58	14
ET_Login	Red	Red	65%	155	101	0

ServiceName	Attribute	Summary
ET_ExchangeTrac	OverallAttribute	Overall Attribute of the BSM_MonitoredApplicationS
ET_ExchangeTrac	OverallAttribute	Overall Attribute of ET_Login is Sep
ET_ExchangeTrac	PctWorseThanAvgRes	PctWorseThanAvgRespTime_Status of the BSM_Mon
ET_ExchangeTrac	PctWorseThanAvgRes	PctWorseThanAvgRespTime of the BSM_MonitoredAp
ET_ExchangeTrac	AvgRespTime	Event based attribute AvgRespTime of template BSM
ET_ExchangeTrac	ResponseTime	Event based attribute ResponseTime of template BSM

What is Predictive Analytics?

Predictive Analytics enable IT organizations to move from reactive to proactive management of services, reducing outages and improving business performance.

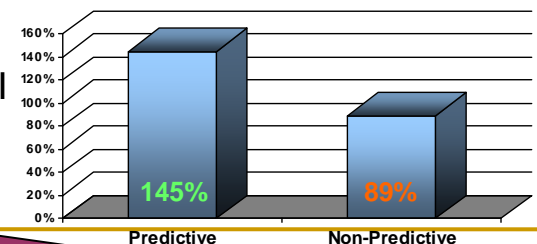
"Analytics leverage data in a particular functional process (or application) to enable context-specific insight that is actionable." - Gartner

Move the sensing and alerting, and eventually actions to earlier and earlier

- Advance warning of service impact, deterioration or outage
- Realistic service baselines
- Avoidance of expensive and time-consuming false alerts
- Detection of service impacts that are not identified by fixed thresholds alone
- Swifter diagnosis of certain events and patterns
- Identification of the underlying root cause to implement fixes

IDC study: Predictive analytics initiatives show an average ROI of **145%**, in comparison to **89%** for non-predictive analytics*

* Source: "Predictive Analytics and ROI: Lessons from IDC's Financial Impact Study" paper, Henry D. Morris



"After we fix the problem, then we set another threshold"

"I'd like 30 minutes warning to know when my user experience is going to deteriorate"

Adaptive Monitoring

Topology Correlation

Predictive Modelling

Self-learning

Forecasting

Anomaly Detection

Dynamic Thresholding

Forward Trending

Operations challenge: Balancing the need to manage more with improved service levels & lower costs



“..multi-dimensional relationships between dynamic infrastructure and changing business services are too complex for IT staff to continue reacting to event storms and constantly tweaking static monitoring thresholds.” *

* Source: PNA, 2008

“40% of unplanned downtime due to operator error” **

** Source: Gartner, March 2009

Challenge: Can you create and maintain increasing numbers of thresholds and situations in a constantly changing IT environment? How can you minimize the number of alerts that operators must handle?

Service Assurance Analytics approach: Intelligent or ‘Predictive Events’ that result from speeding the ability to detect abnormal trends before end users and mission critical applications are impacted

“I’d like my operators to be able to more quickly diagnose certain events and patterns to implement fixes.”

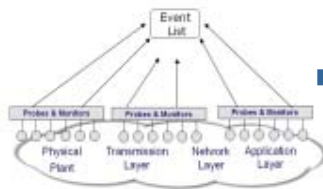
“We have too many thresholds to maintain”

“I’d like to adjust for repeating traffic situations”

Maturation of Monitoring and Analytics



Receive trouble tickets. Fault!
React to user report



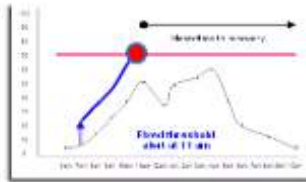
Gather alerts
React to events,
before user report



Gather & Correlate alerts
React to events,
w/ improved RCA



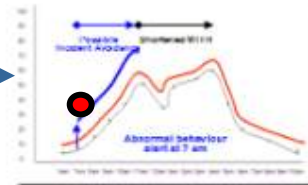
Add performance monitor
React to performance
changes



Static Thresholds
Set reasonable thresholds
thresholds, create alerts
when violated



Linear Forecasting
Linear prediction
One metric



Dynamic Thresholds
Earlier Detection
based on history

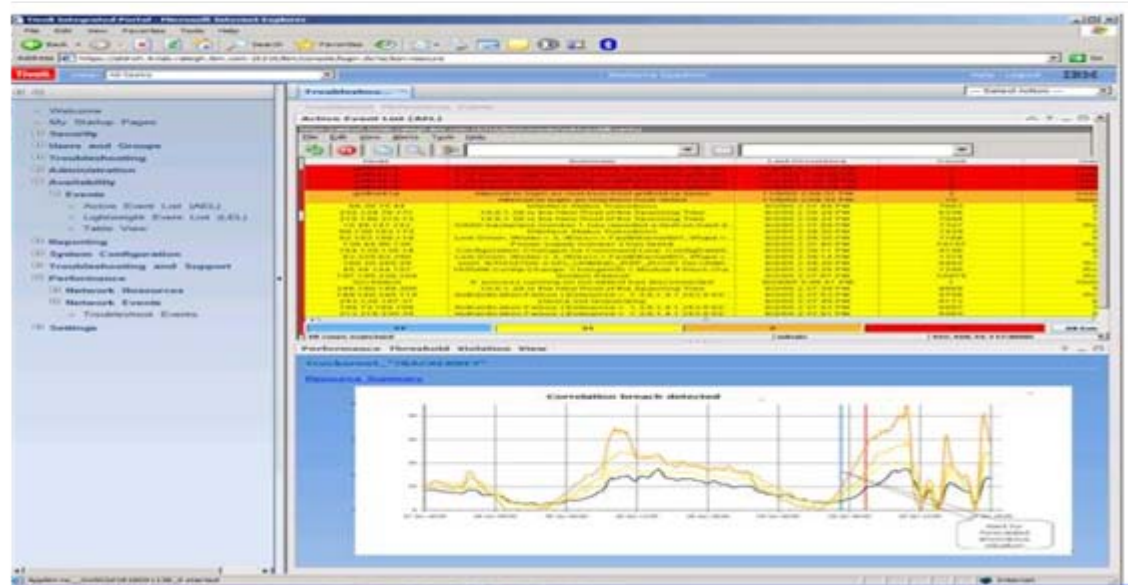


Nonlinear Forecasting
More accurate prediction of
single metric

Monitoring and Analytics Approaches

Where we're going

- Low latency analysis of performance and wellness data in motion across physical and virtual infrastructures, from across the service delivery stack (from servers to hypervisors to networks to applications)
- Advanced univariate, and multivariate predictive analysis
 - With behavioral learning algorithms that can learn normal behavior during operation, and react to changes



What are the use cases?

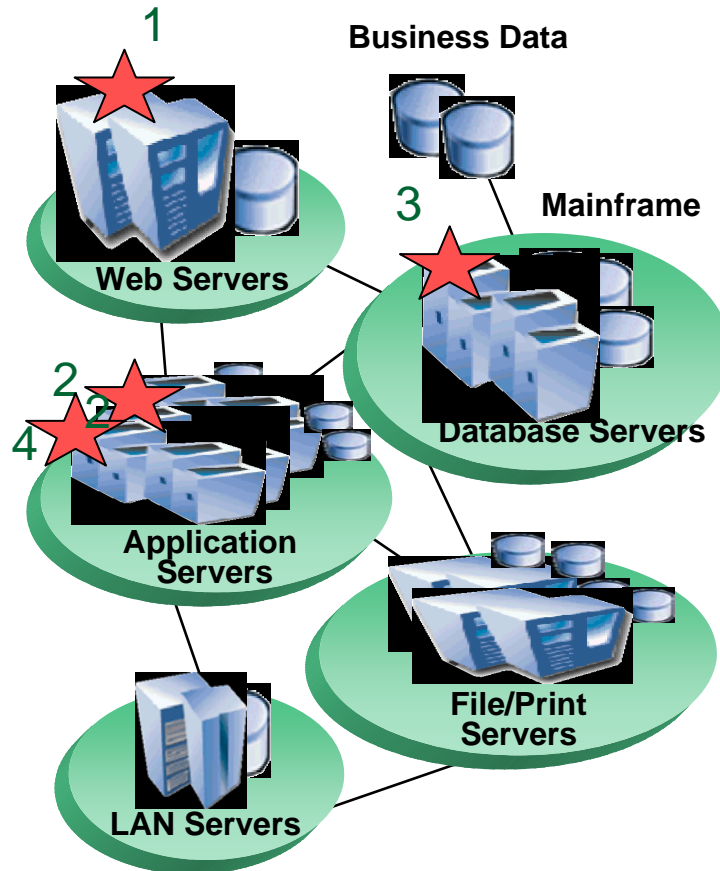
Learning algorithms build a model of relationships between KPIs

“DMZ”

Security,
Proxy Servers

DNS,
Caching

Load Balancing
Application Acceleration



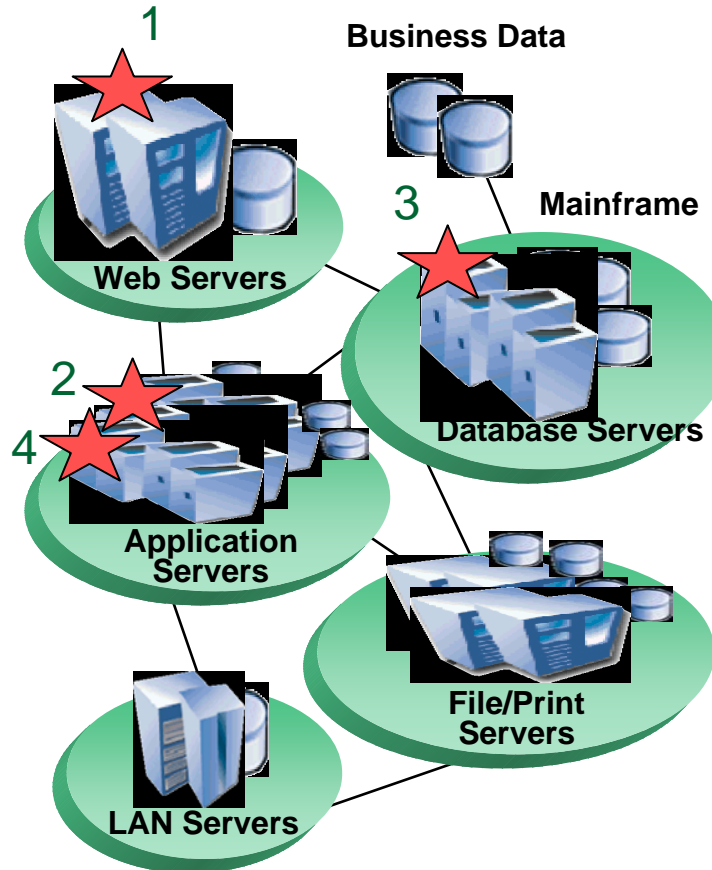
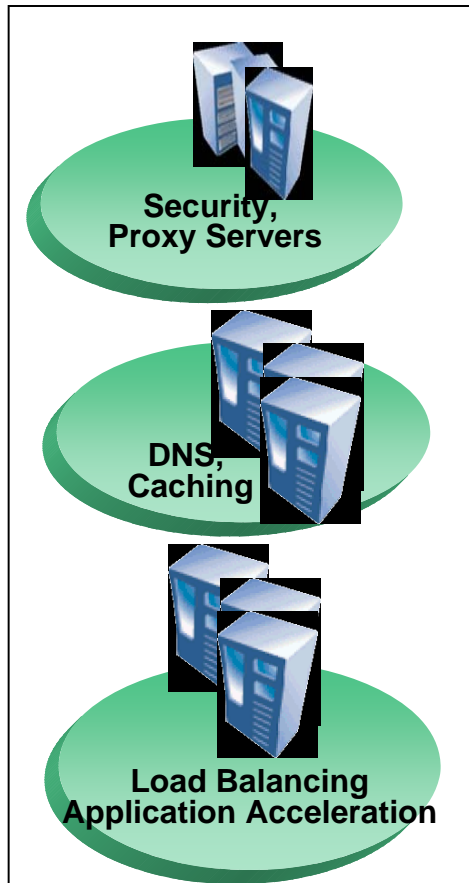
1. Web server traffic
2. Application memory
3. I/O accesses
4. Application performance

Web server traffic, application memory, and I/O accesses trend up and down together. Application performance trends opposite.

Identify relationships that were previously unknown.
Identify patterns in KPI performance between resources.

Case 1: Identify anomalies that could not be found with single KPI thresholds

“DMZ”



1. Web server traffic stable
2. Application memory rising
3. I/O accesses stable
4. Application performance within normal range

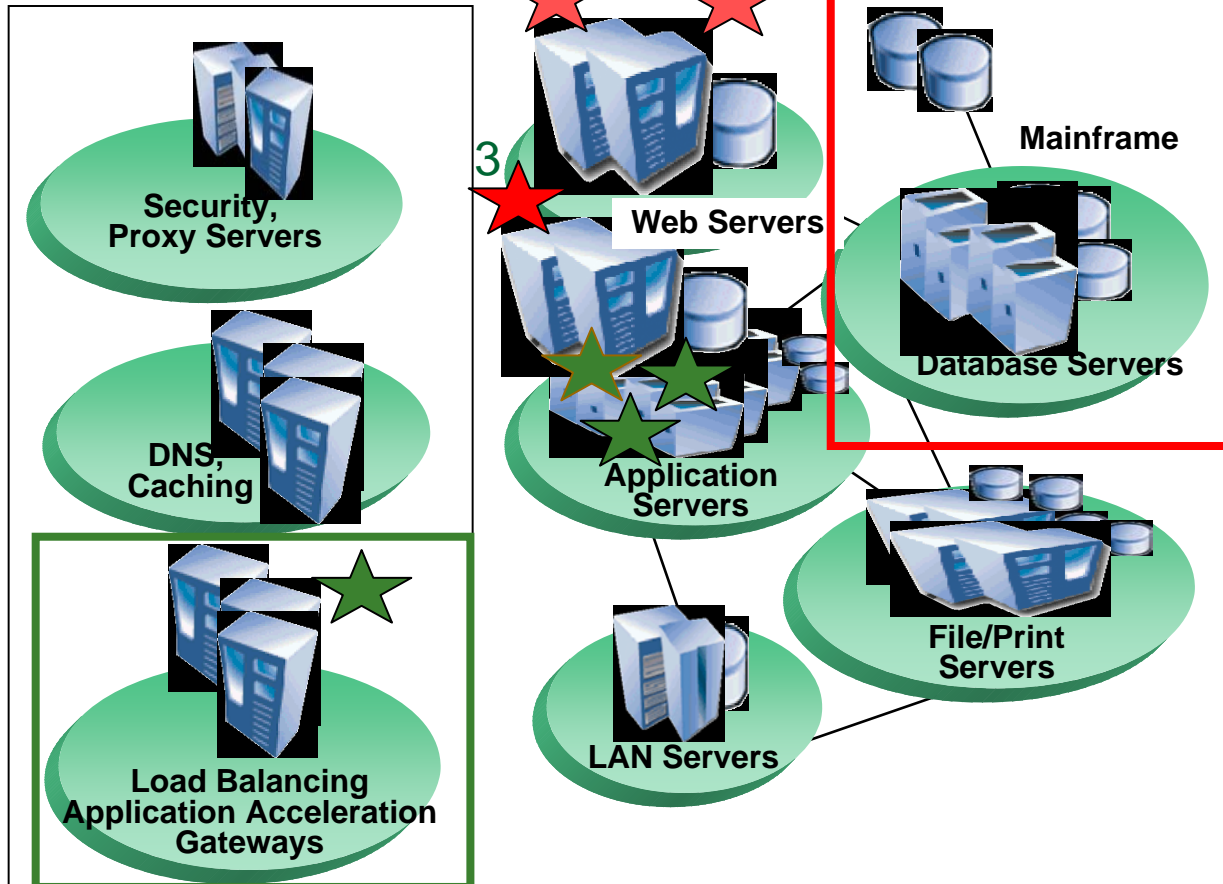
Identify emerging problem, even if all still “green”

Memory leak!

Identify anomalies you can't find with single KPI thresholds

Case 2: Identify problems in resources not in your management domain

“DMZ”



1,2,3 – Web servers response times

- Previously uncorrelated Web servers response times become correlated with each other.
- Problem in a downstream resource in a different management domain- SAN errors

Green stars – Applications performance degradation

- Gateway problems

Identify “outside” problems that will affect service

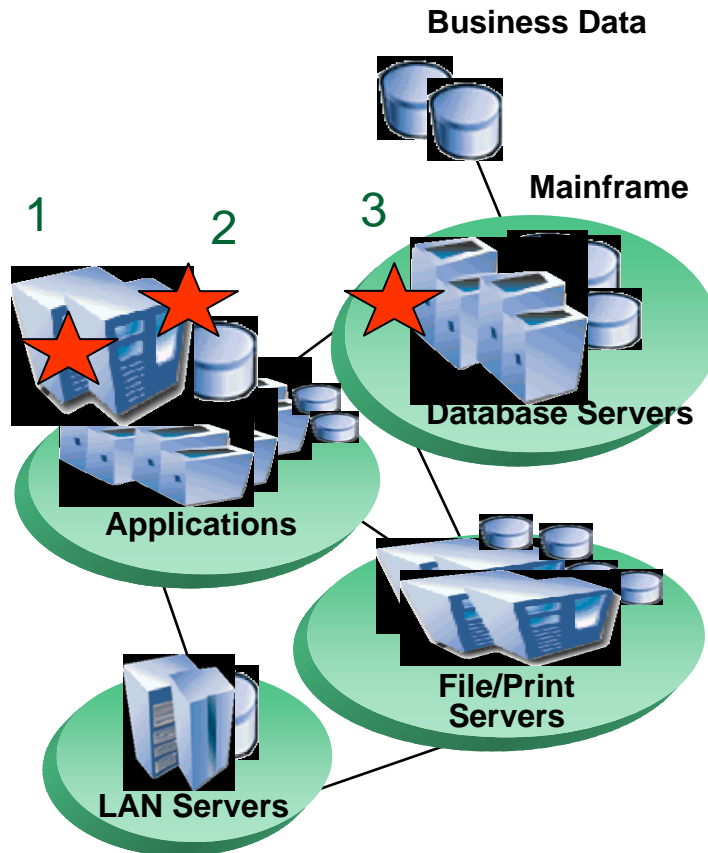
Case 3: Identify problems in use of shared resources

“DMZ”

Security,
Proxy Servers

DNS,
Caching

Load Balancing
Application Acceleration
Gateways



Application performance (1), VNIC utilization (2) and DB traffic (3) are related. More traffic, lower performance.

Analysis shows: Application performance degrades, but VNIC utilization and DB do not show corresponding increases.

Root cause: New application deployed on same physical server. Server I/O being “hogged” by other VMs. Issue identified before retraining complete, before service levels breached

Identify resource issues caused by injudicious deployment of applications on a shared infrastructure

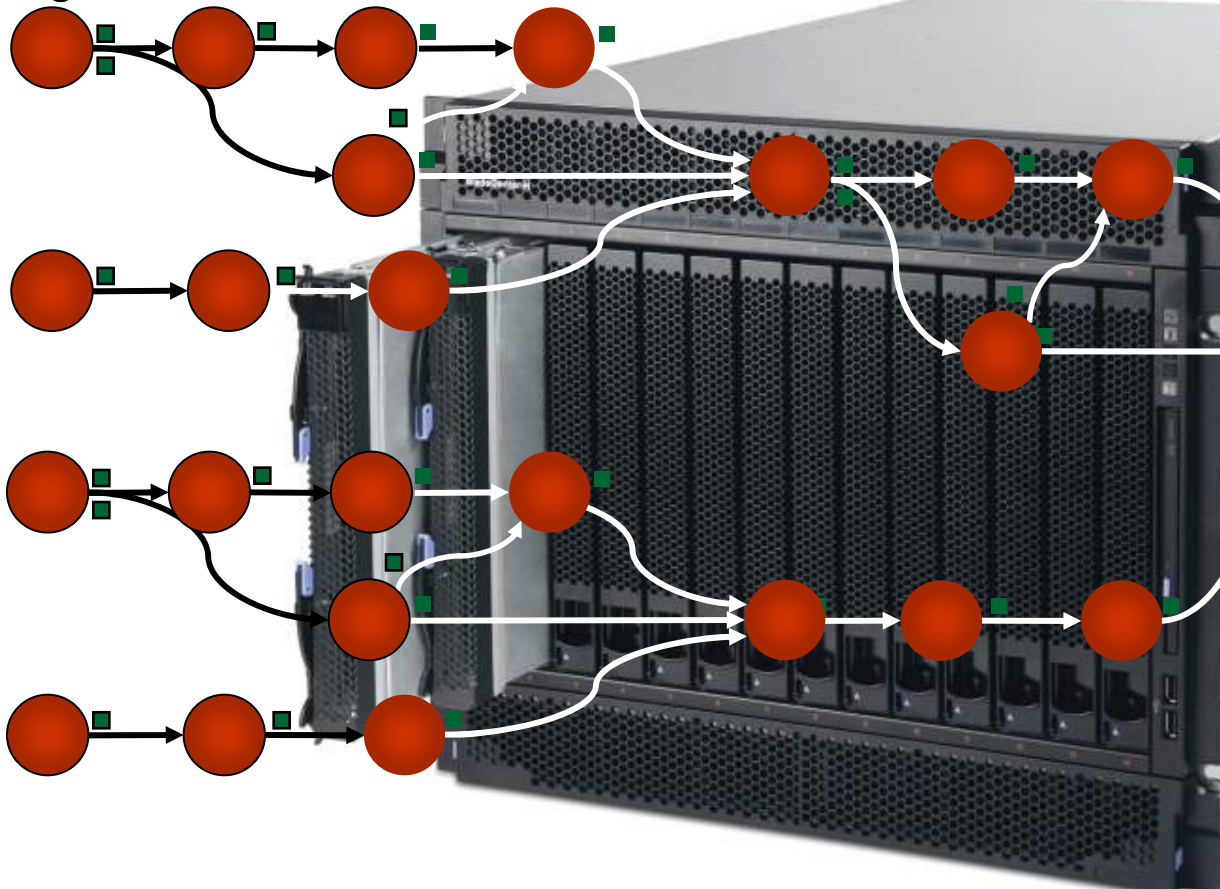
Streaming analytics engine

Continuous



Continuous Complex Analysis in
Microseconds

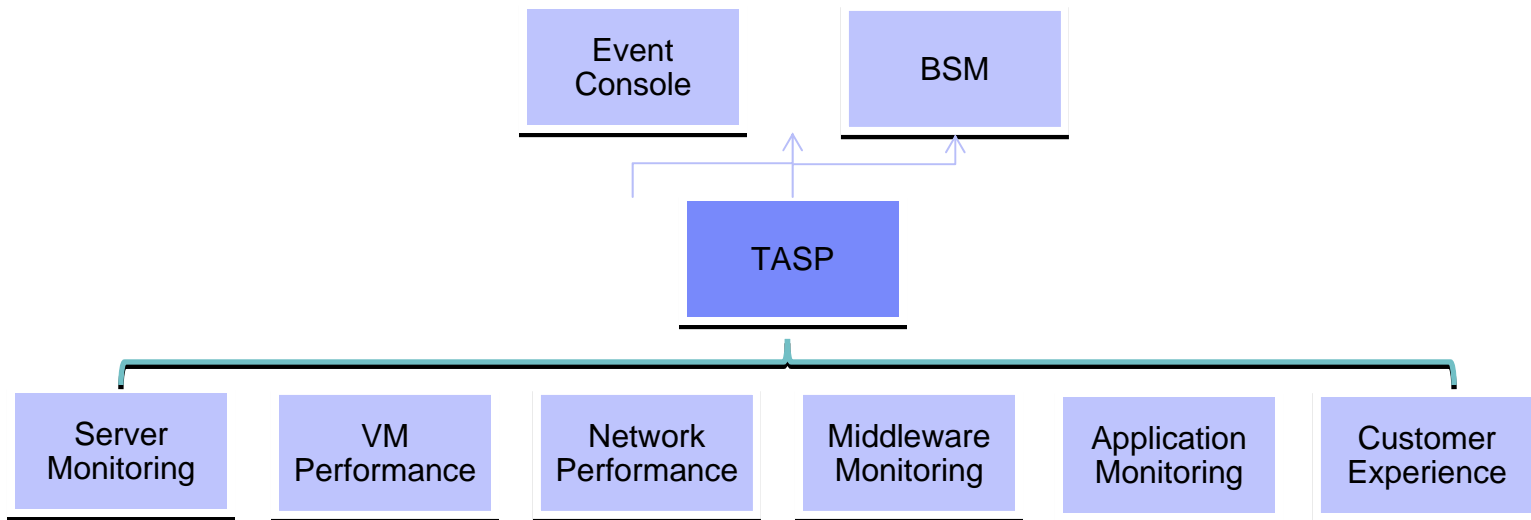
Ingestion



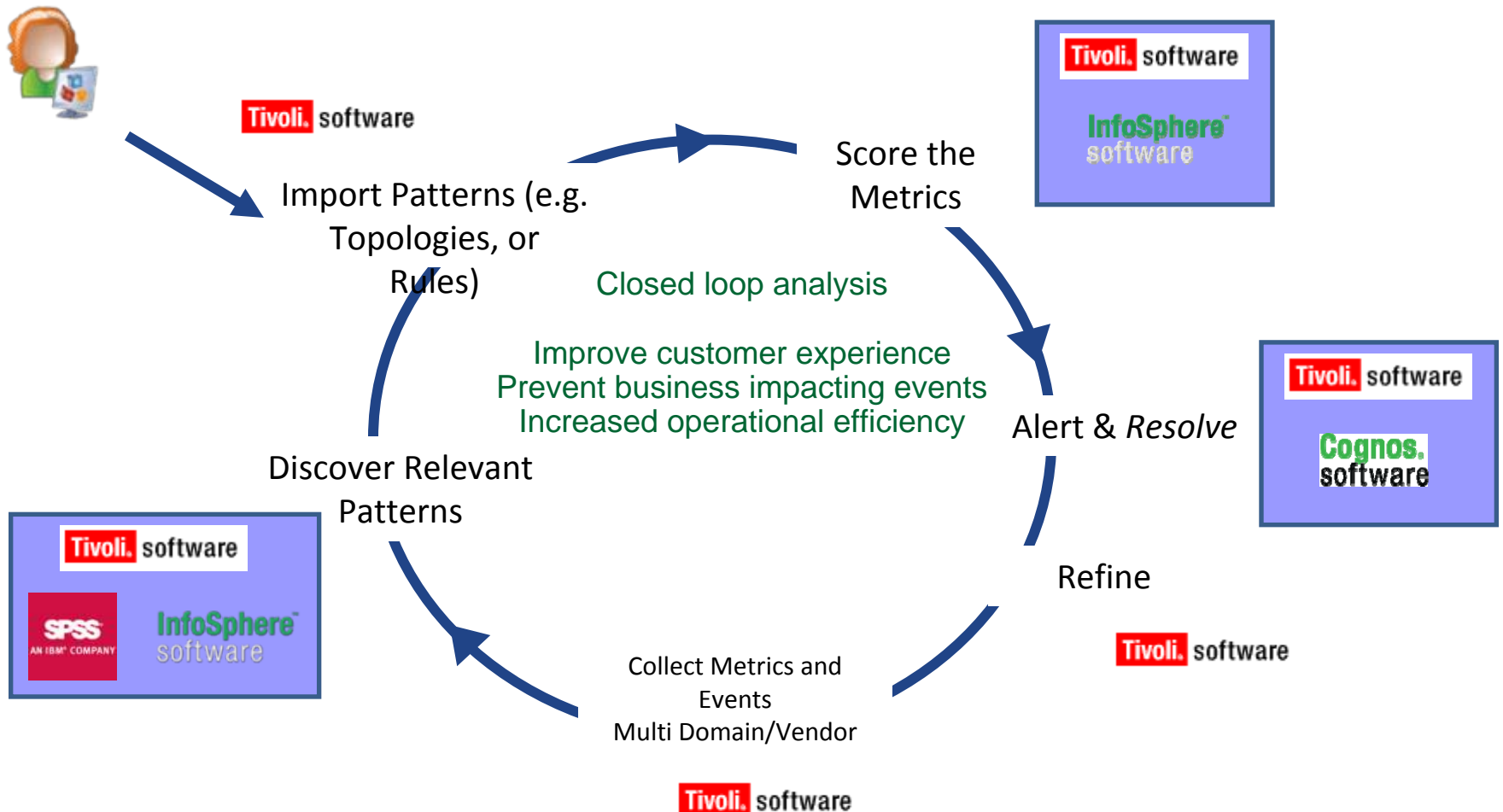
- Processes millions of events per second
- Used in finance, manufacturing, law enforcement

TASP:


- R yhu#k#h#r#s#d#q#d#o#w#l#f#v#z#k#l#f#k#h#y#h#u#d#j#h#{#l#w#l#q#j#p#r#q#l#w#r#u#l#q#j#v#|#v#w#h#p#v#/#d#q#d#o#}#l#q#j#p#h#w#l#f#v#i#u#r#p#s#k#|#v#l#f#d#d#l#q#g#y#l#w#x#d#h#q#y#l#u#r#q#p#h#q#w
- X v#h#v#/#d#q#d#o#w#l#f#v#r#h#d#u#q#r#u#p#d#h#s#h#u#d#w#l#r#q#d#d#e#h#k#d#y#l#r#x#u#d#f#u#r#v#v#k#h#f#a#r#x#g#l#q#i#u#d#v#w#x#f#w#u#h
- O#h#d#u#q#v#p#d#w#k#h#p#d#w#l#f#d#d#h#o#d#w#l#r#q#v#k#l#s#v#e#h#w#z#h#h#q#p#h#w#l#f#v#d#f#u#r#v#v#k#|#s#h#u#y#l#r#u#v#/#P#v#d#q#g#r#w#k#h#h#h#p#h#q#w#l#q#k#h#v#h#u#y#l#f#h#g#h#o#l#y#h#u#|#w#d#f#n#l
- G#h#w#h#f#w#s#u#r#e#d#p#v#e#h#i#r#u#h#k#h#|#e#h#f#r#p#h#e#x#v#l#q#h#v#v#p#s#d#f#w#l#q#j#l
- V#h#q#g#v#d#q#r#p#d#o#|#h#y#h#q#w#r#p#d#q#d#j#h#p#h#q#w#f#r#q#v#r#d#v#l

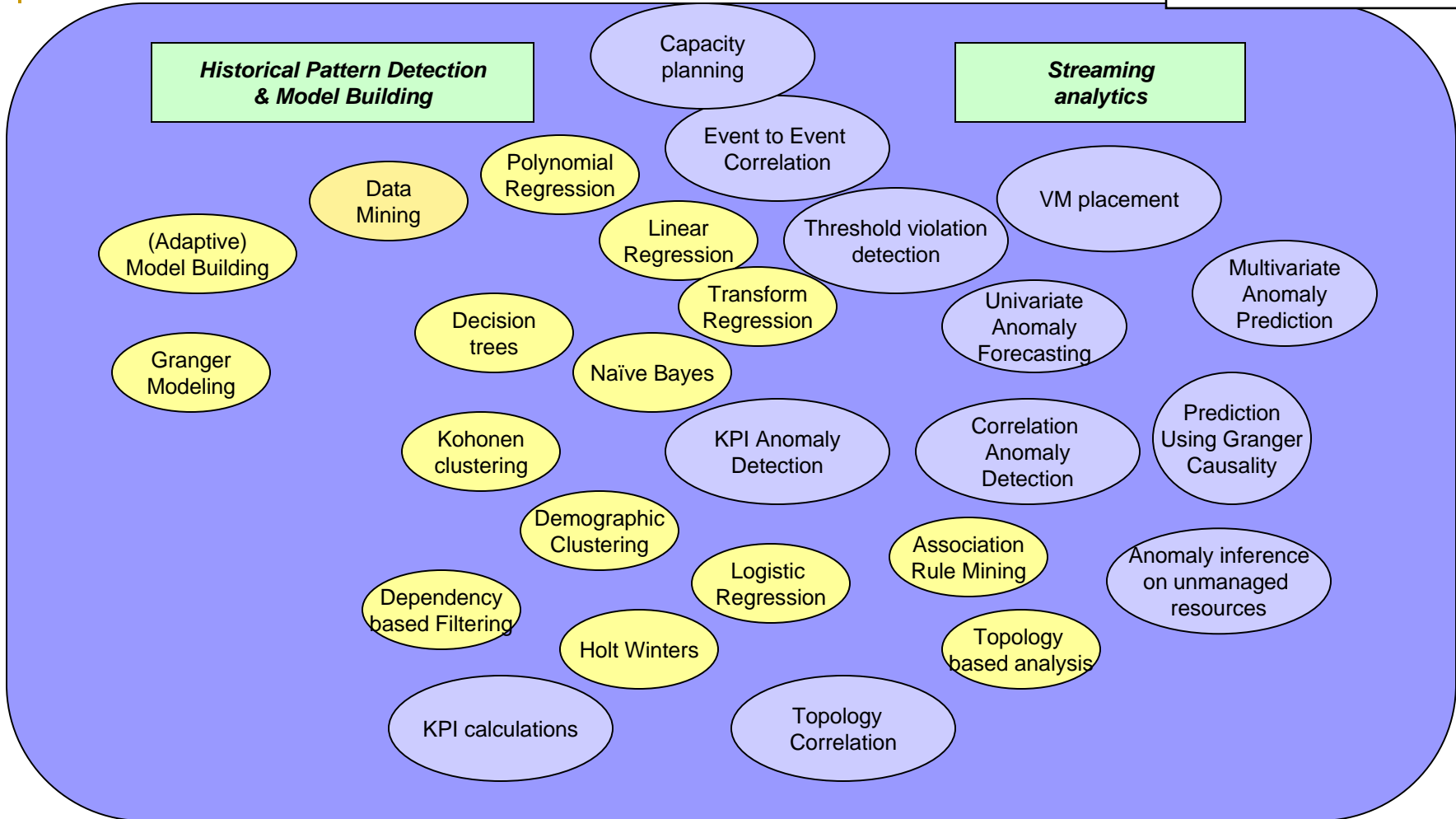


Tivoli's Predictive Analytics Lifecycle



Analytics Landscape

Techniques	
Scenarios	

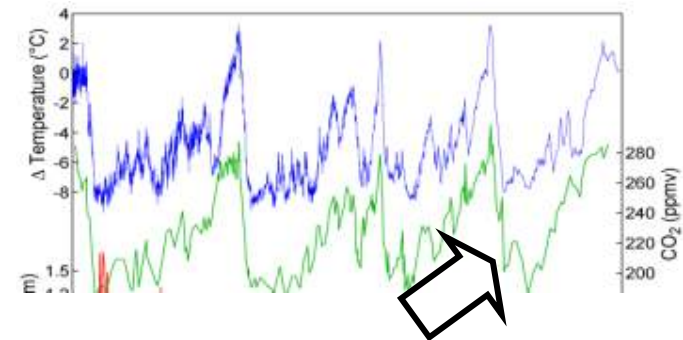


Methodology: Temporal Causal Modeling by Graphical Granger Modeling

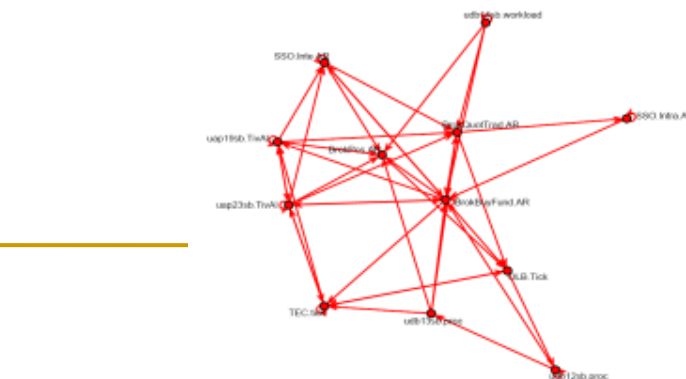
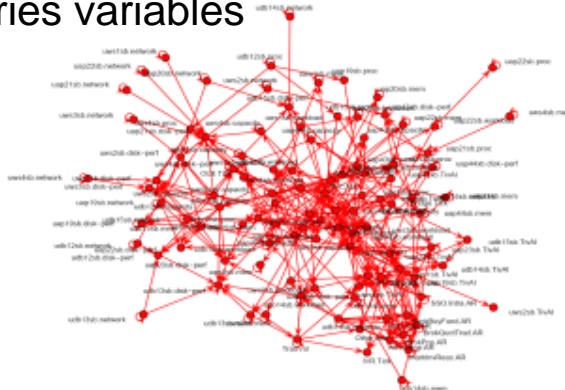
- Granger causality
 - First introduced by the Nobel prize winning economist, Clive Granger
- Definition: a time series x is said to “Granger cause” another time series y , if and only if regressing for y in terms of both past values of y and x (1) is statically significantly better than that of regressing in terms of past values of y only (2)

$$y_t \approx A \cdot y_{t-1} + B \cdot x_{t-1} \quad (1)$$

$$y_t \approx A \cdot y_{t-1} \quad (2)$$



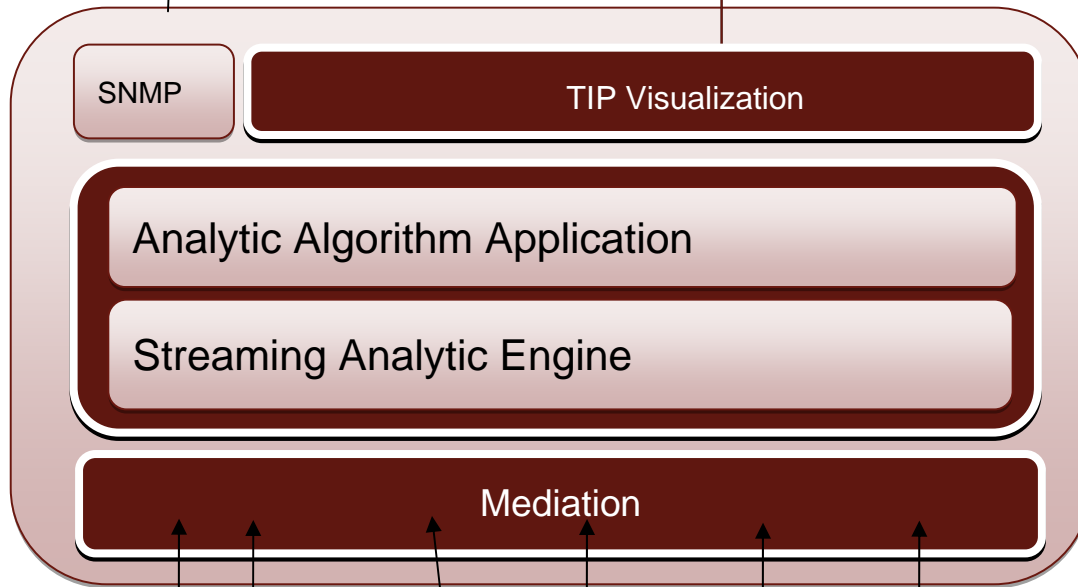
- Combination of Granger Causality and cutting-edge modeling techniques provides efficient and effective methodology for Granger causal modeling of a large number of time series variables



Service Assurance Analytics



3rd Party Event Consoles



- Leverages IBM Information Management assets to field a state of the art solution
- Highly scalable and resilient streaming analytics engine
- Powerful analytics algorithms, combining multiple approaches, designed to leverage the analytics engine for extensive scalability
- Highly flexible and scalable data mediation layer providing turn key integrations and easily extendable capabilities
- SNMP and Netcool/Omnibus native predictive alerts

Demo Screenshots: Event received



View: All tasks | Welcome: tpadm1 | Help | Logout | IBM

iscFragmentBanner

Active Event List (AEL) | --- Select Action ---

Active Event List (AEL)

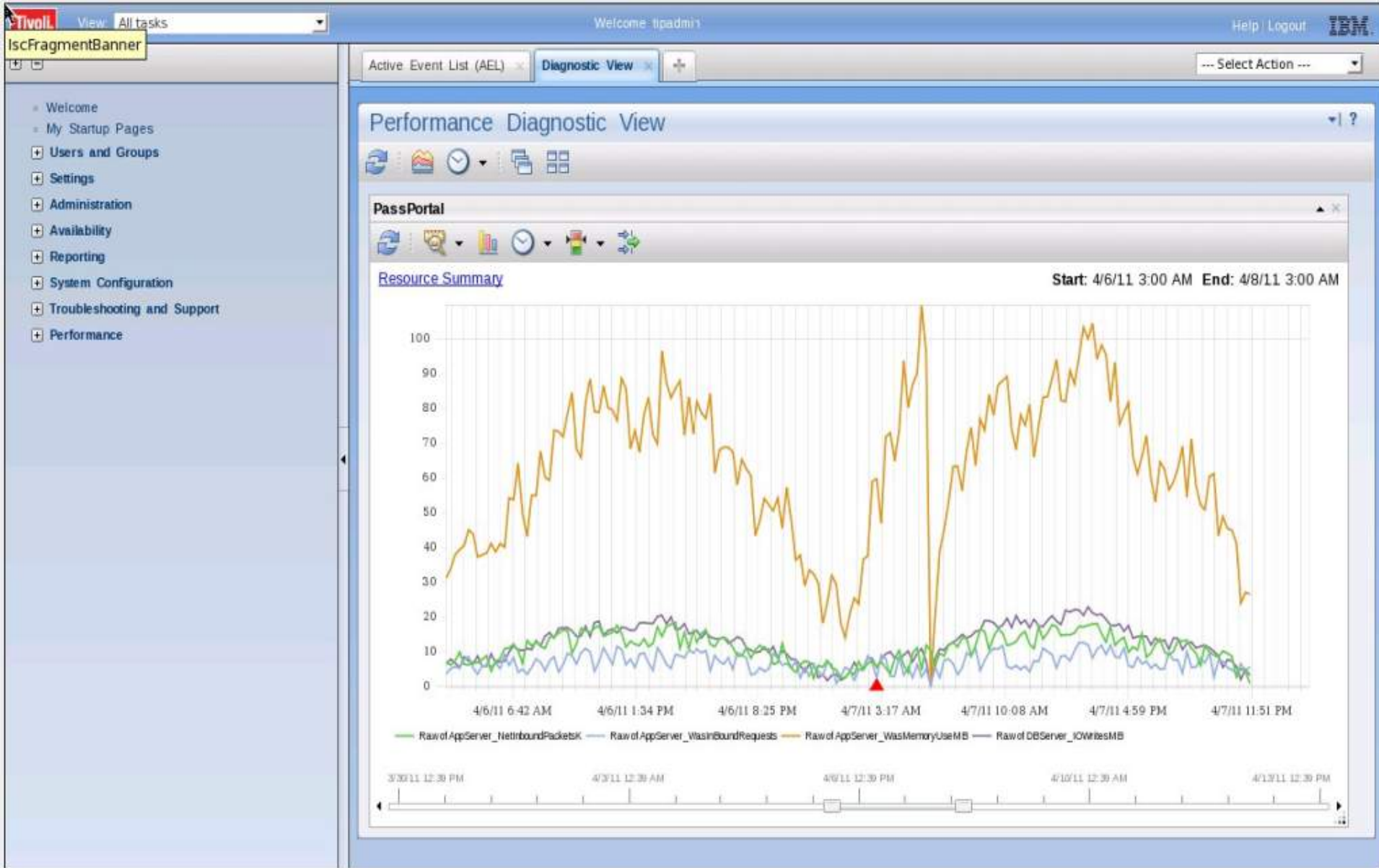
Default

Sev	Ack	Node	Alert Group	Summary	Last Occurrence	Count
6	No	PassPortal		Anomaly detected on PassPortal	4/7/11 3:00:00 AM	1

0 rows inserted, 0 rows updated, and 0 rows deleted. | Data Source(s): NCOMS | QuickFilter: None | Auto refresh in: 57 sec.

All Events (1)

Investigation

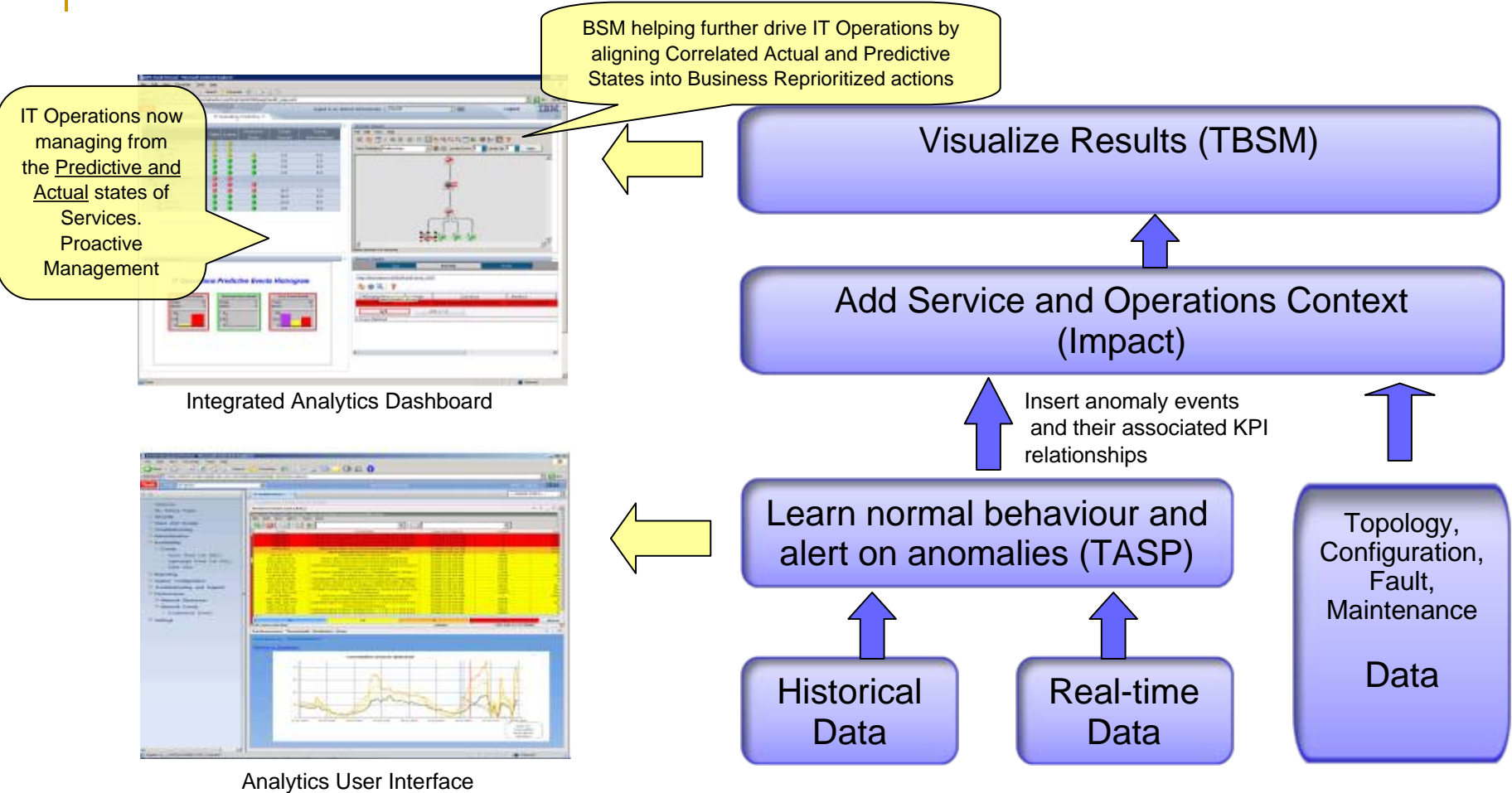




Adding in Pertinent Events



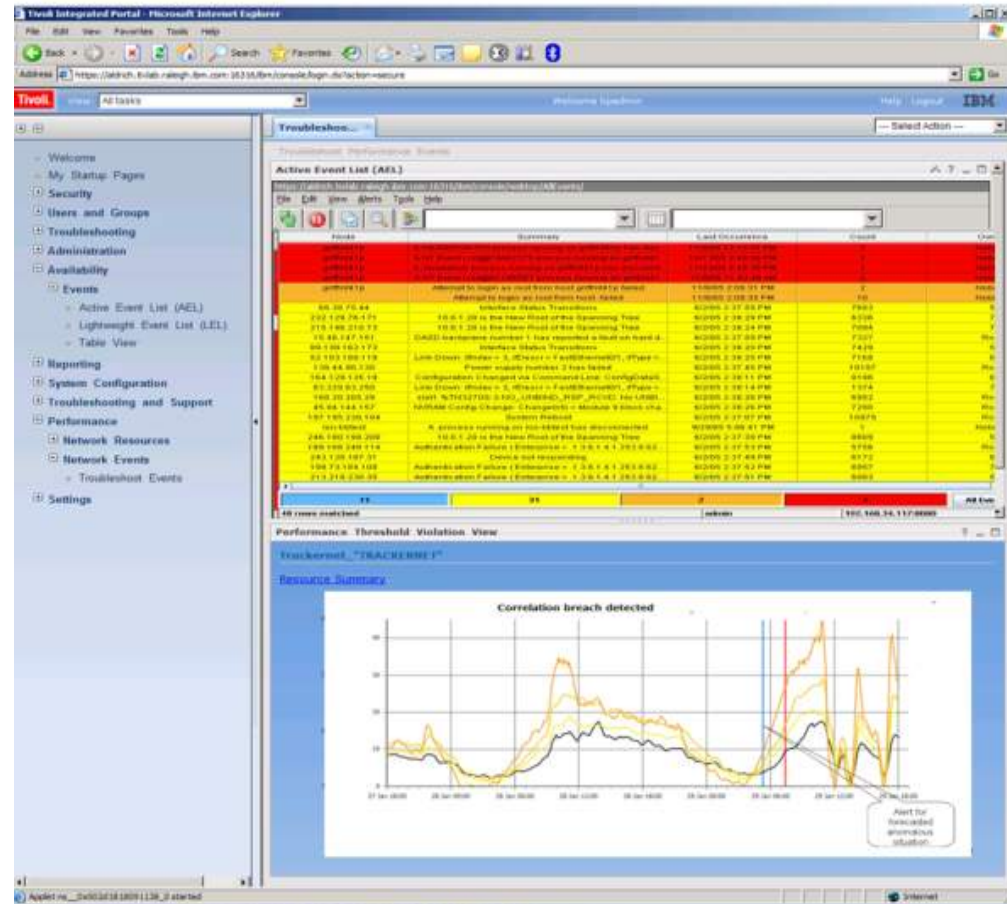
Visualize Predictive Analytics in Business Context



Tivoli's solutions allows you see anomalous conditions prioritized for business impact associated with other environmental data, such as faults, configurations changes, maintenance activities, etc...

Service Assurance Analytics

- Identify anomalous KPI behavior without any thresholds.
 - Leverage existing managed data.
- Leverage near real time streaming analytics to identify complex, multi-domain interactions and subtle emerging problems across domains
- Warn users in advance of service impact, deterioration or outage.
 - Learning algorithms which learn normal behavior, with ability to adapt to changes
- Focus on usefulness of results, not on individual algorithms.
 - Add new algorithms over time, without requiring users to become analytics experts.



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Communities

- **On-line communities, User Groups, Technical Forums, Blogs, Social networks, and more**
 - Find the community that interests you ...
 - **Information Management** ibm.com/software/data/community
 - **Business Analytics** ibm.com/software/analytics/community
 - **Enterprise Content Management** ibm.com/software/data/content-management/usernet.html
- **IBM Champions**
 - Recognizing individuals who have made the most outstanding contributions to Information Management, Business Analytics, and Enterprise Content Management communities
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