Cloud Monitoring

A challenging Application for Complex Event Processing

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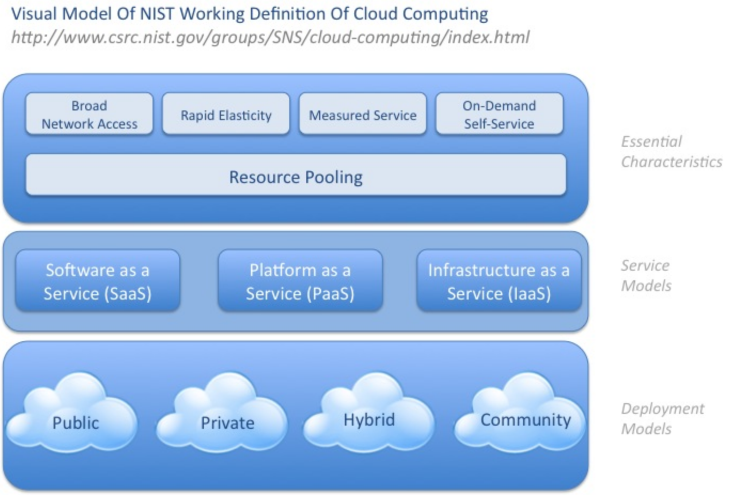
Agenda

- Introduction and motivation
- Design and implementation
- Examples
- Conclusion and research issues

The NIST-Definition of Cloud Computing



High Potential of Cloud Computing

The use of cloud computing leads to

- more flexibility and mobility
- lower costs of IT

BITKOM is expecting

- sales of 8.2 billion euro in 2015 in Germany
- 50 % average growth of sales per year up to 2015

Over 75 % of all enterprises are interested in cloud computing[1]

[1] Symantec Corporation: „Virtualization and Evolution to the Cloud Survey".

State of the Art

Over 80 % of all enterprises aren't in the cloud[2], because of

- reliability risks (78 %)
- security risks (76 %)
- performance risks (76 %)
- lack of monitoring and management tools (63 %)

ENISA has worked out 35 critical risks and recommends

- the use of public clouds only for non-critical data
- the permanent holding ready of an exit strategy

[2] Stratecast Research Group: „Overcoming Obstacles to Cloud Computing".

Challenges in Cloud Monitoring

- Monitoring in real-time
- Dynamic scalability
- Holisitic monitoring
- Flexibility and extensibility
- Powerful and custom analysis (inter-layer monitoring)
- Control of single cloud components
- Prediction of trends (proactive monitoring)

Cloud Monitoring: A Killer Application for CEP

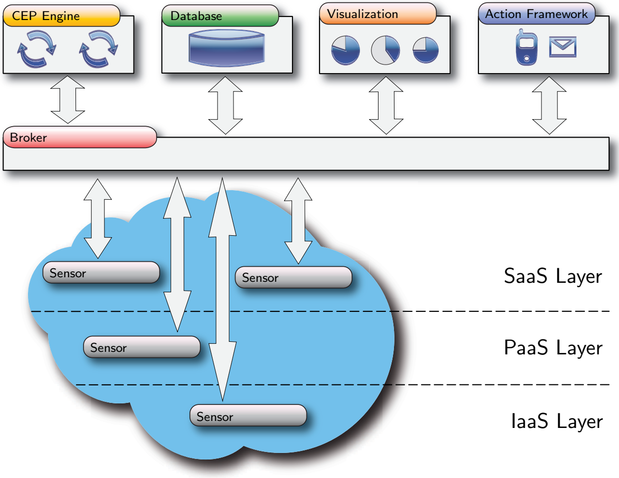
Mass of sensor data has to be processed in real-time

- 1 mio. physical and 60 mio. virtual machines (OpenCloud)
- 120 PB storage cluster with 200.000 disks (IBM)

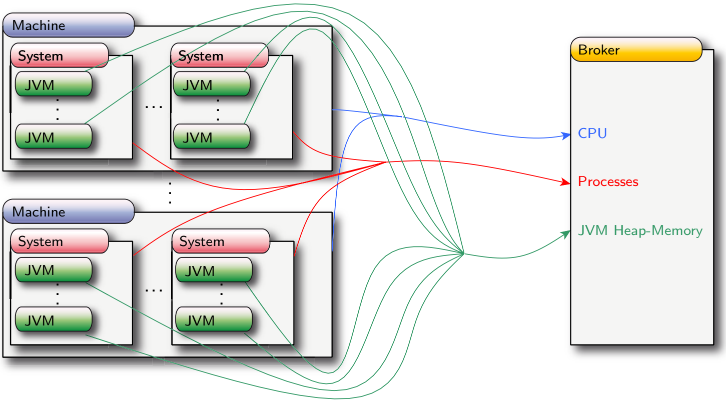
Mass of monitoring rules has to be executed continuously

- Customers have individual SLAs
- Each SLA results in custom monitoring rules

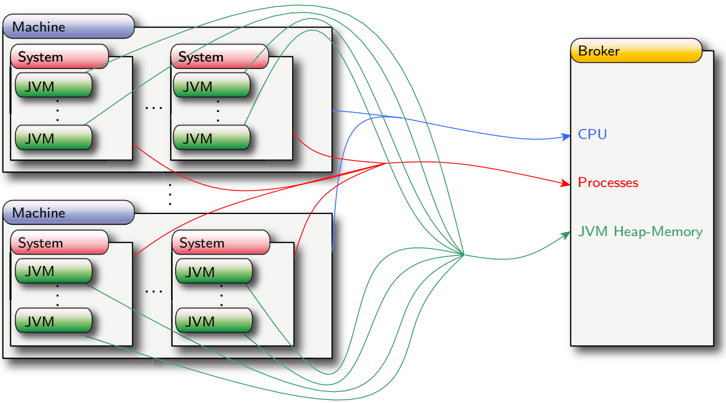
General Architecture of *CEP4Cloud*



Logical view on sensor streams:



Effective Communication: Data Stream Design (2/2)



Optimization of real sensor streams

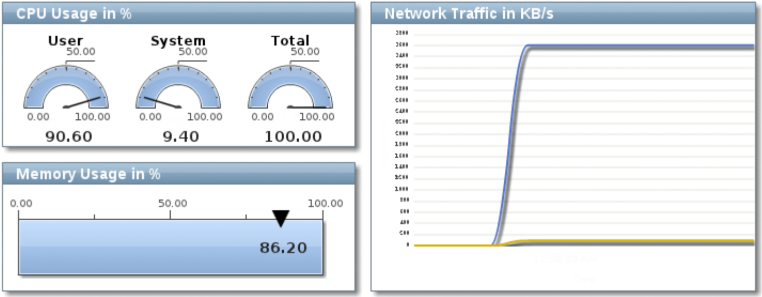
1. Bundles of single events and complete streams (less messages)
2. Compression on each bundle (lower size of messages)

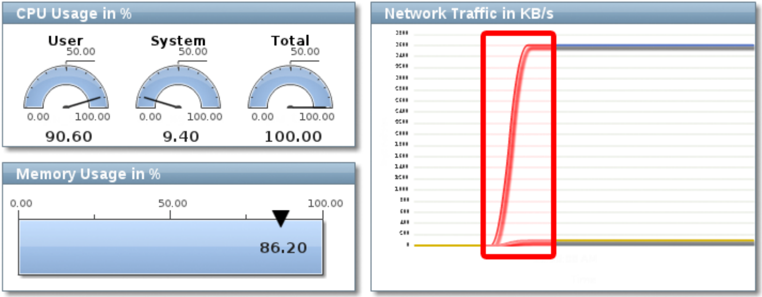
Benefits of a SQL-based CEP-Engine

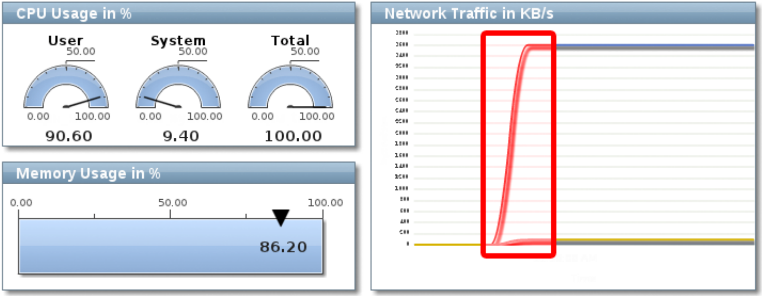
- Inter-layer analysis (depends on the data model)
- Full declarative power of SQL + pattern matching
  - Easy creation/modification of continuous queries at runtime
  - High performance through continuous query optimization
- Solid base for advanced data stream mining techniques
  - Pattern detection
  - Period detection
  - Anomaly detection
  - Frequent itemsets
  - Classification
  - Trends
  - Evolutions
  - ...

This makes a big difference to current monitoring tools!

Example 1: Monitoring the IaaS-Layer (1/3)

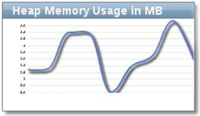


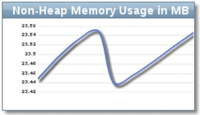

CPU Usage in %
User
50.00
0.00
100.00
90.60
System
50.00
0.00
100.00
9.40
Total
50.00
0.00
100.00
100.00
Memory Usage in %
0.00
50.00
100.00
86.20
Network Traffic in KB/s




```sql
SELECT    ip_address,
          avg(bytes_in), avg(bytes_out),
          stddev(bytes_in), stddev(bytes_out)
FROM      NetworkSensor WINDOW(RANGE 1 MINUTE)
GROUP BY  ip_address
HAVING    stddev(bytes_in)  > 0.2 * avg(bytes_in)
OR        stddev(bytes_out) > 0.2 * avg(bytes_out);
```

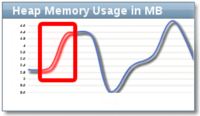
Example 2: Monitoring the PaaS-/SaaS-Layer (1/4)

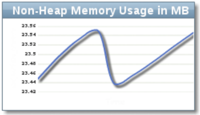




Live Threads

Thread ▲	State	CPU in %	BlockedTime	#Blocked	WaitedTime	#Waited
CompilerThread0	WAITING	0,3	0,000 s	0	30 m 29 s	1760
Finalizer	WAITING	0,0	0,002 s	10	28 m 49 s	11
Low Memory Detector	BLOCKED	0,0	0,526 s	1755	29 m 30 s	1168
main	WAITING	0,0	0,006 s	147	28 m 46 s	85
Reference Handler	BLOCKED	0,1	0,009 s	220	28 m 49 s	194
Signal Dispatcher	WAITING	0,0	0,000 s	8	0 m 0 s	9
Thread-13	RUNNABLE	18,3	0,015 s	21	0 m 6 s	12
Thread-8	WAITING	0,0	0,000 s	0	28 m 46 s	634
Timer	BLOCKED	0,0	0,012 s	541	29 m 49 s	5300





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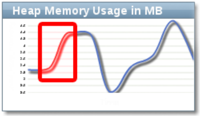

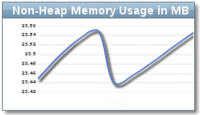

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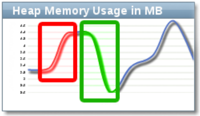
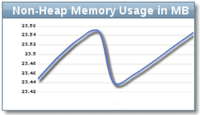
```
SELECT j.jvm_key, (j.used_heap_memory
  - past.avg_heap_memory) / past.avg_heap_memory * 100
FROM   JVMMemorySensor j,
       (SELECT jvm_key,
               avg(used_heap_memory) AS avg_heap_memory
        FROM JVMMemorySensor WINDOW(RANGE 2 SECONDS)
        GROUP BY jvm_key) past
WHERE  j.jvm_key = past.jvm_key;
```

Example 2: Monitoring the PaaS-/SaaS-Layer (4/4)





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        GROUP BY jvm_key) past
WHERE  j.jvm_key = past.jvm_key;
```

Additional Functionality on Top of *CEP4Cloud*

- Security monitoring
- Real-time or proactive control of cloud infrastructure
- Guarantee of SLAs

Research Issues

- Elasticity of *CEP4Cloud*
- Automatic installation/configuration of *CEP4Cloud* agents
- Query advisor for parameters, thresholds and new queries

Project of Software AG and University of Marburg

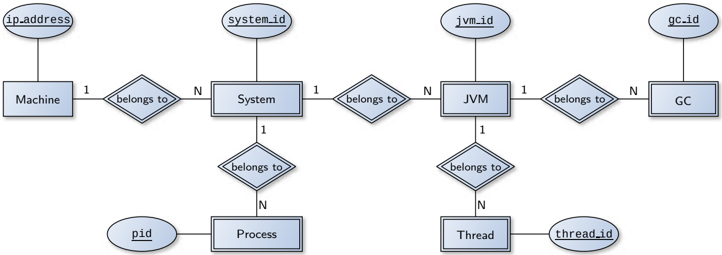
- Hannover (Germany): CeBit 2011
  - Visual demonstration of first ideas
- Berlin (Germany) & Orlando (USA): Process World 2011
  - Joint venture between Software AG + University of Marburg
  - Live presentations of *CEP4Cloud*

Backup Slides

1. Data model
2. Pattern matching
3. Inter-layer analysis

Enabler of complex Analysis: Basic Data Model

Relationships among different layers must be modeled:



There are more entities and other relationships in a cloud

- 'Clouds' (one monitoring instance for parallel running clouds)
- 'Users' (profiling, fraud detection)
- ...

Example 3: Pattern Matching

```
SELECT threadKey, threadState
FROM   JVMThreadSensor
MATCHING( PARTITION BY thread_key
          MEASURES threadKey String,threadState String
          PATTERN 'ab{4}'
          WITHIN 1 MINUTE
          DEFINE a DO  threadKey = thread_key,
                       threadState = thread_state
                 b AS  thread_key = threadKey
                   AND thread_state = threadState );
```

Example 4: Inter-Layer Analysis

```
SELECT  process_key, process_memory
FROM    ProcessSensor p,
        (SELECT ip_address, max(process_memory) AS maxi
         FROM ProcessSensor WINDOW(RANGE 10 SECONDS)
         GROUP BY ip_address) sub,
        MemorySensor WINDOW(RANGE 10 SECONDS) m
WHERE   p.ip_address = sub.ip_address
AND     p.ip_address = m.ip_address
AND     p.process_memory > 0.8 * sub.maxi
AND     m.mem_free / m.mem_total < 0.2;
```