IT-Capacity Analysis and Forecasting with KNIME and R

Markus Schmid
T-Systems International GmbH

KNIME UGM Zurich, 2014-02-12

T · · Systems ·

AGENDA

T-Systems

Capacity Management: Scope and Challenges

Capacity Reporting with KNIME: Architecture

Real-Life examples (KNIME/R/BIRT)

- Resource level
- Service-Level

Forecast-Approach

Lessons learned

Summary

ABOUT T-SYSTEMS

- **T-Systems International:**
  - present in more than 20 countries worldwide
  - 52.000 employees in total, about 23.000 in Germany
- **T-Systems provides IT Services for the Deutsche Telekom Group as well as for external customers**

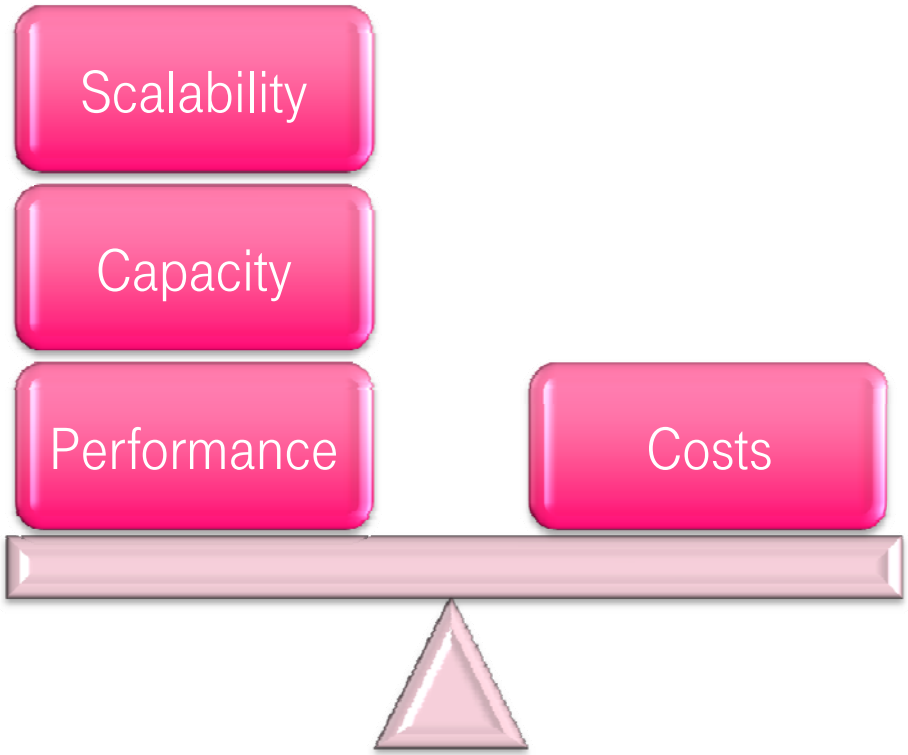
  - **Telekom-IT:**
    T-Systems division with focus on
    - Applications development & operation
    - IT support for complex business processes

    for the Customer Deutsche Telekom

IT CAPACITY MANAGEMENT: SCOPE

Balancing of Costs and Capacity

„As small as possible, still as big as necessary“



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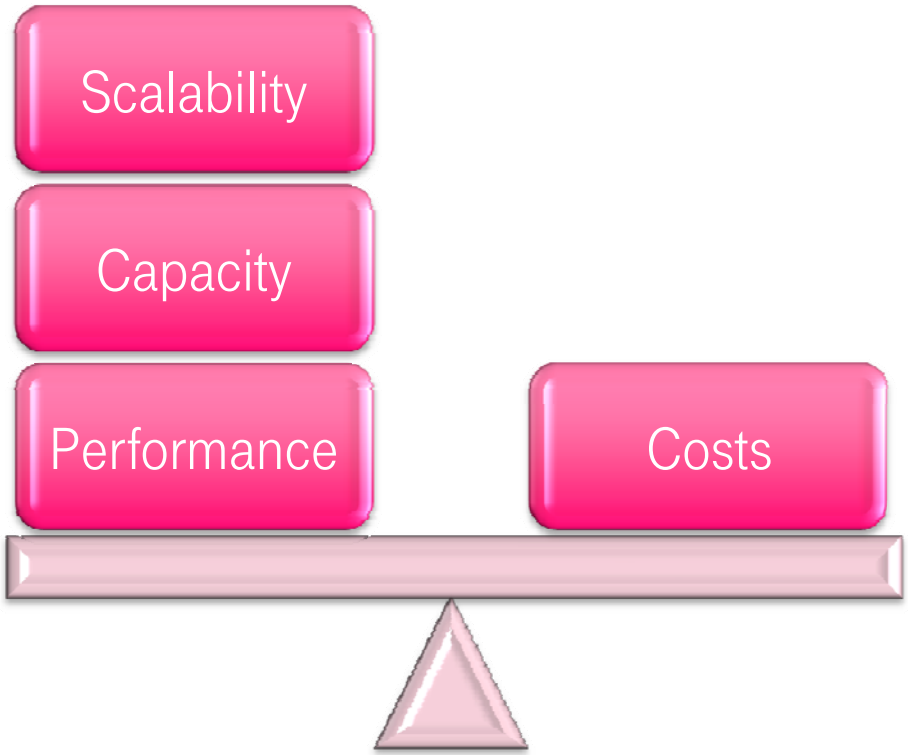

- Scope:
  - IT-Capacity
    (primarily logical and physical server infrastructure, storage)
    - Initial sizing for new projects
    - Capacity monitoring and forecasting for systems in operation

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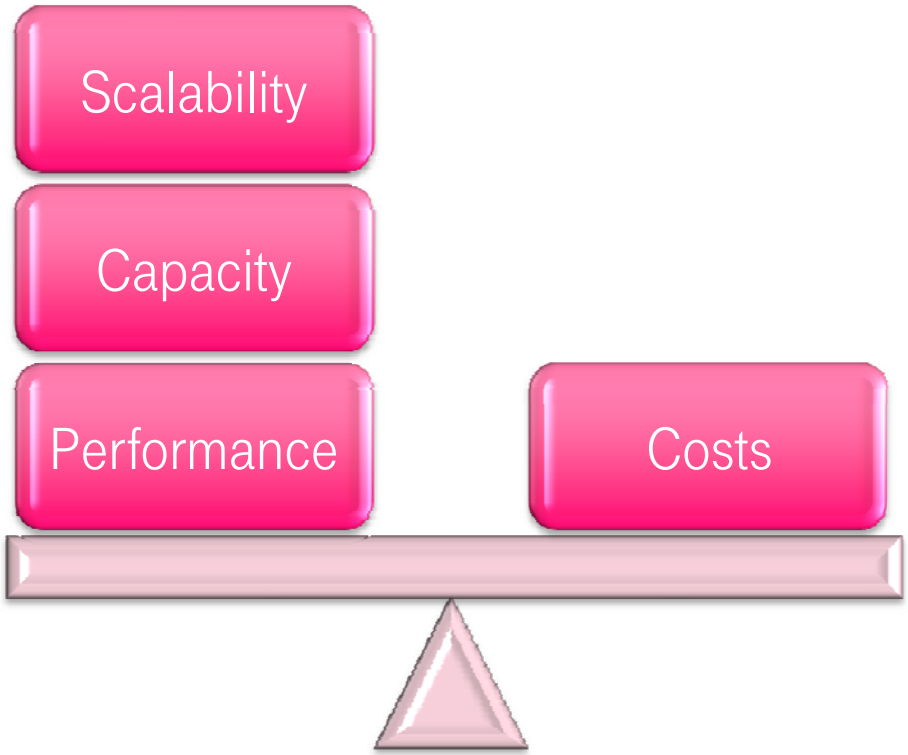

- Scope:
  - IT-Capacity
    (primarily logical and physical server infrastructure, storage)
    - Initial sizing for new projects
    - Capacity monitoring and forecasting for systems in operation
- Non-Scope:
  - Staff
  - Desktop systems

CAPACITY MANAGEMENT: COMBINED EVALUATION OF TECHNICAL MONITORING DATA AND BUSINESS DATA

Purpose of IT infrastructure: Support of business processes

- technical monitoring depicts load that is typically caused by business activities
- In a telecommunications company typically complex process chains that involve a number of
  - business support systems (BSS)
  - operations support systems (OSS)

Business development has a direct impact on system load

- provisioning of additional capacity depends on underlying platform (classic servers, virtualization, cloud-environments)

➔Evaluation of business forecasts is essential for balanced capacity provisioning

CAPACITY REPORTING & FORECASTING

Capacity reporting

- Did things work out as planned?
- Are there long-term trends to react to?
  - Avoidance of capacity problems and incidents

Capacity forecasting

- Evaluate the impact of business forecasts to IT infrastructure
- Challenging in large-scale deployments
  - Permanent change in
    - processes
    - applications and interfaces
    - technical infrastructure

ARCHITECTURAL OVERVIEW

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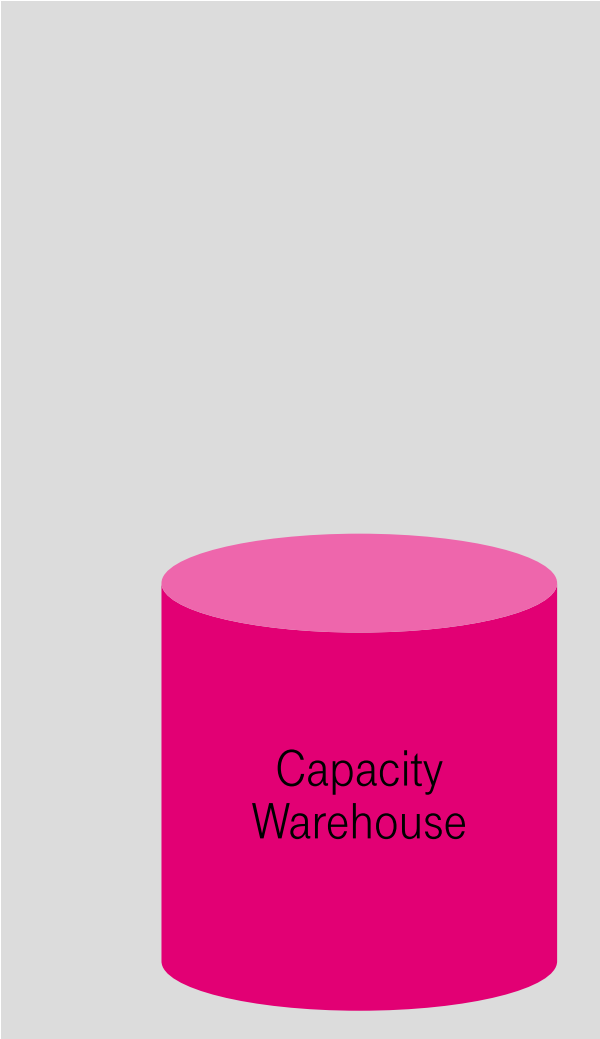

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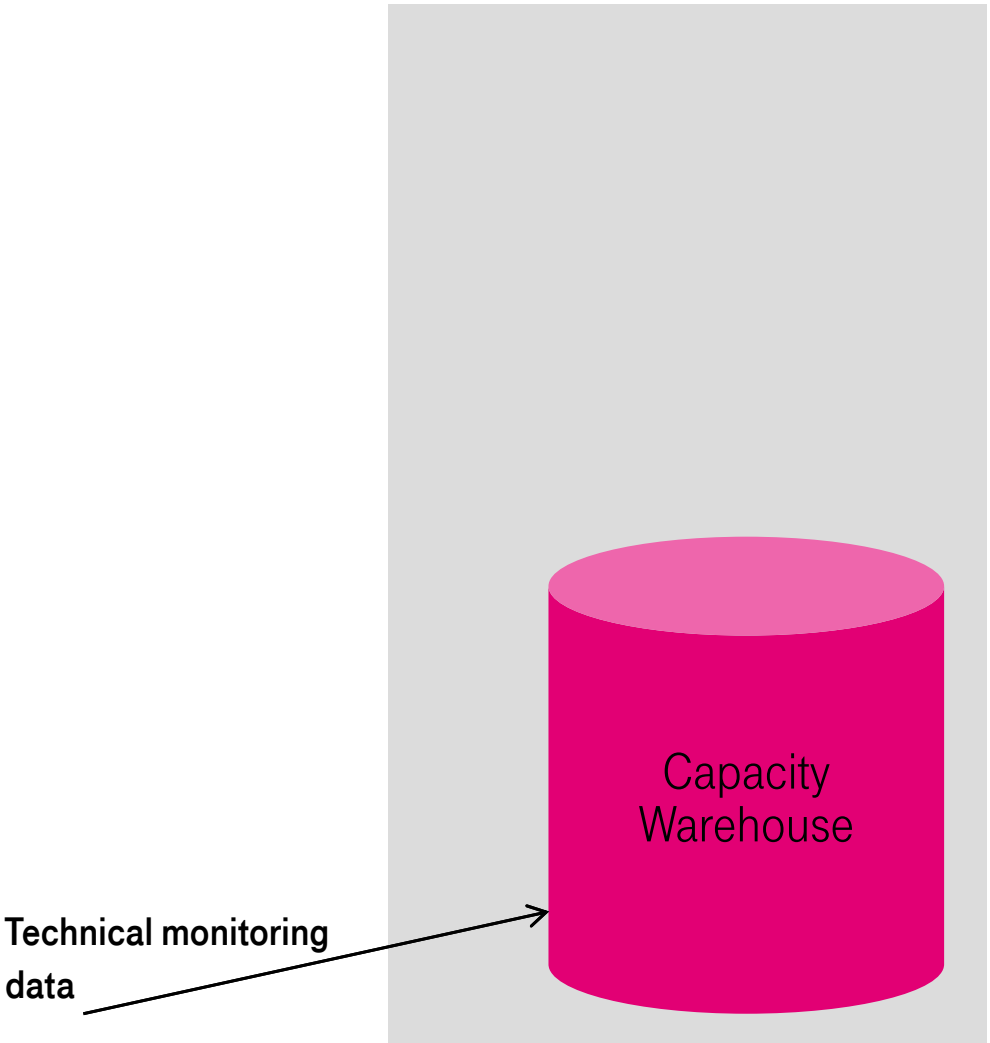

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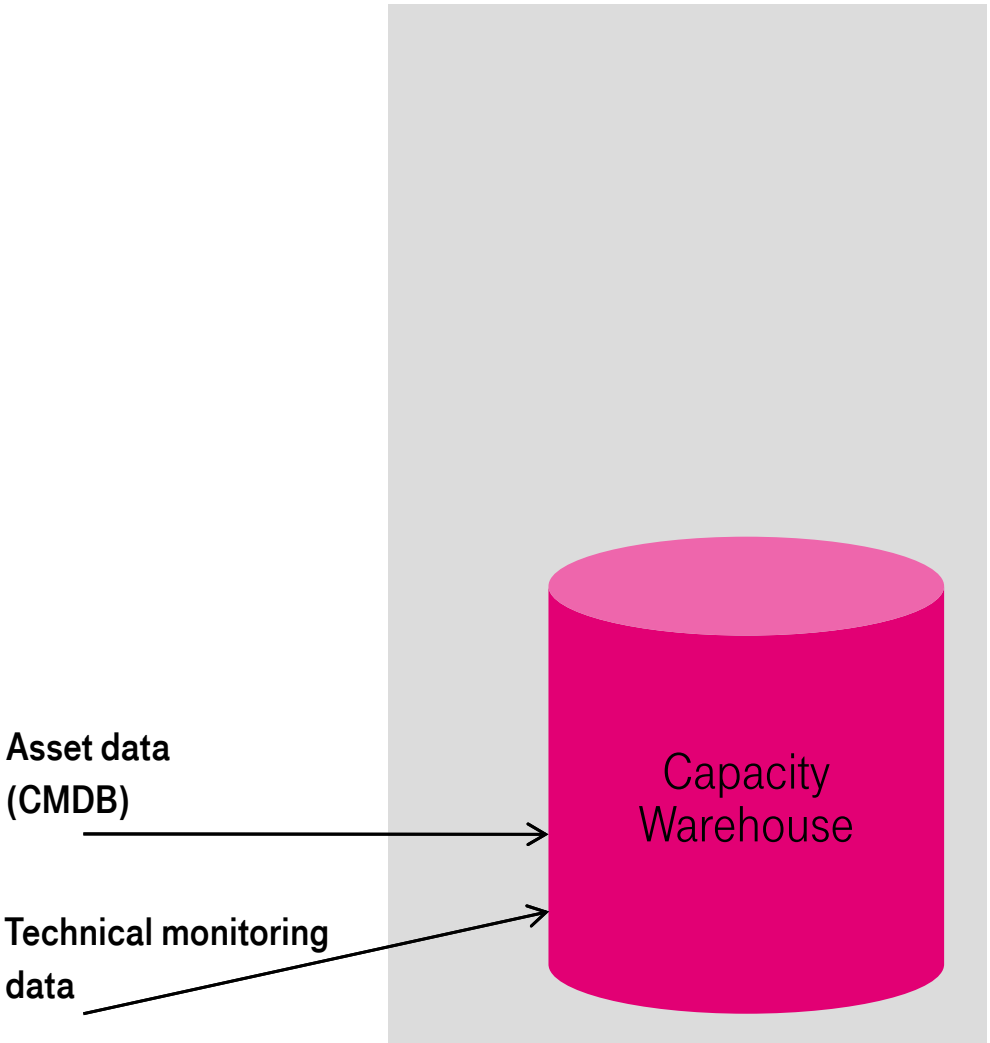

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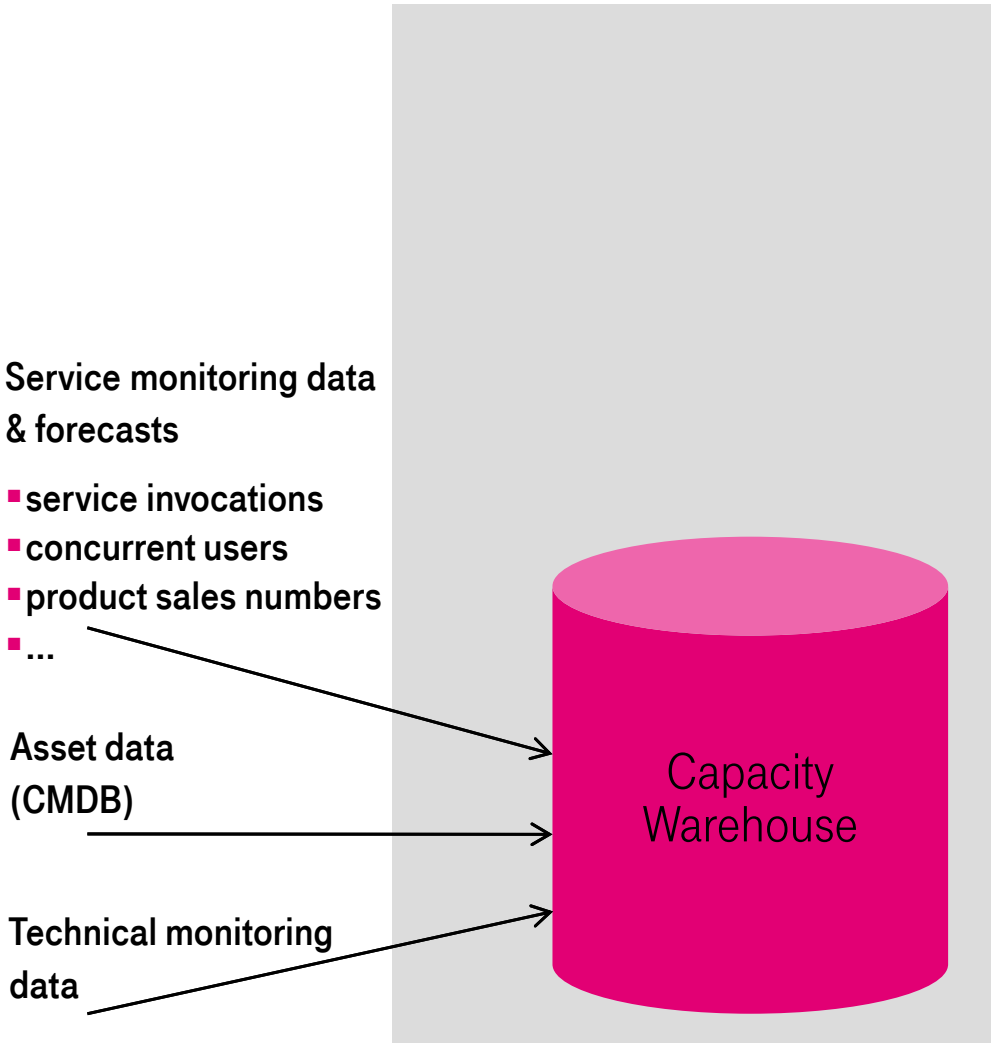

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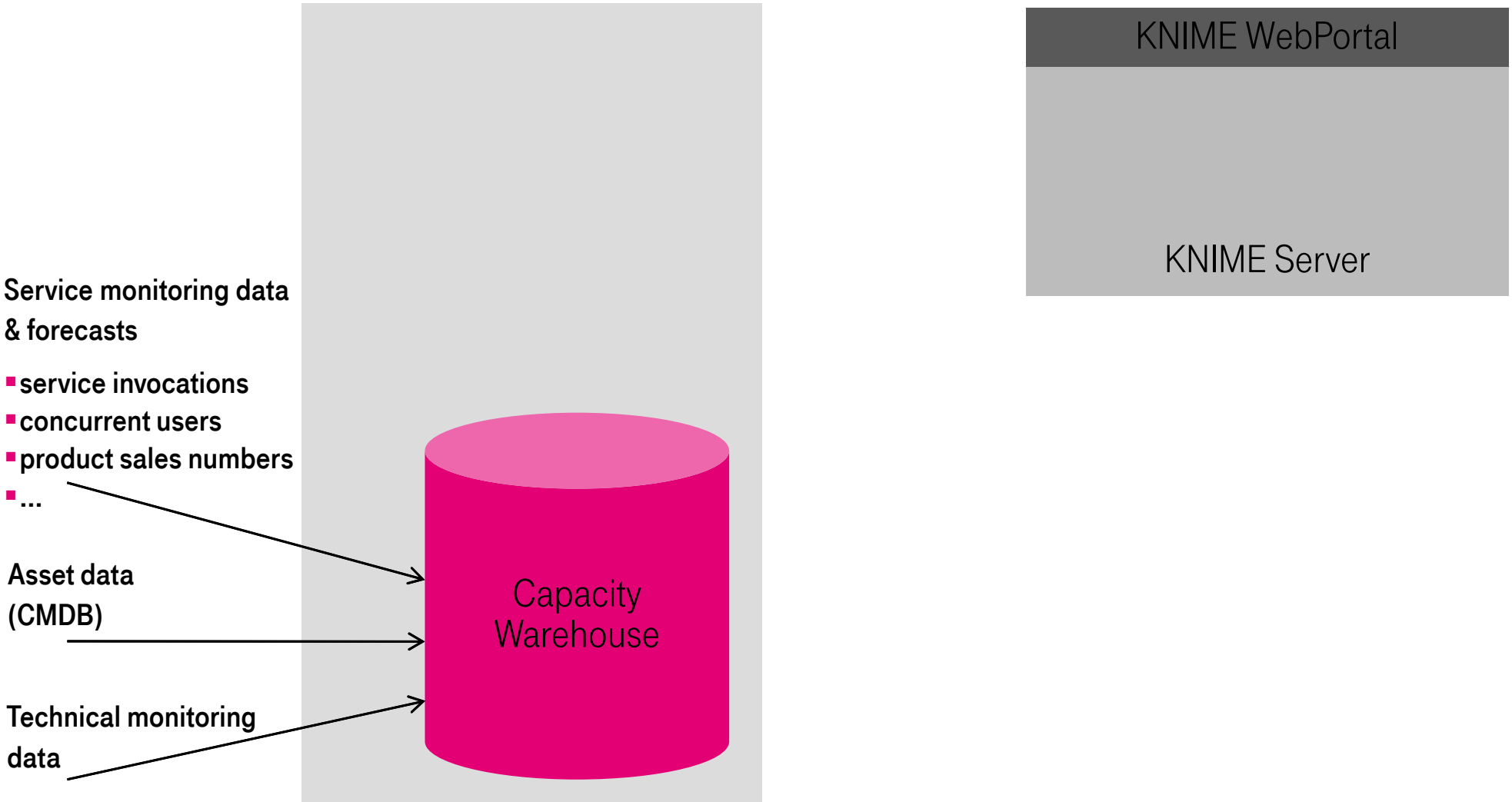

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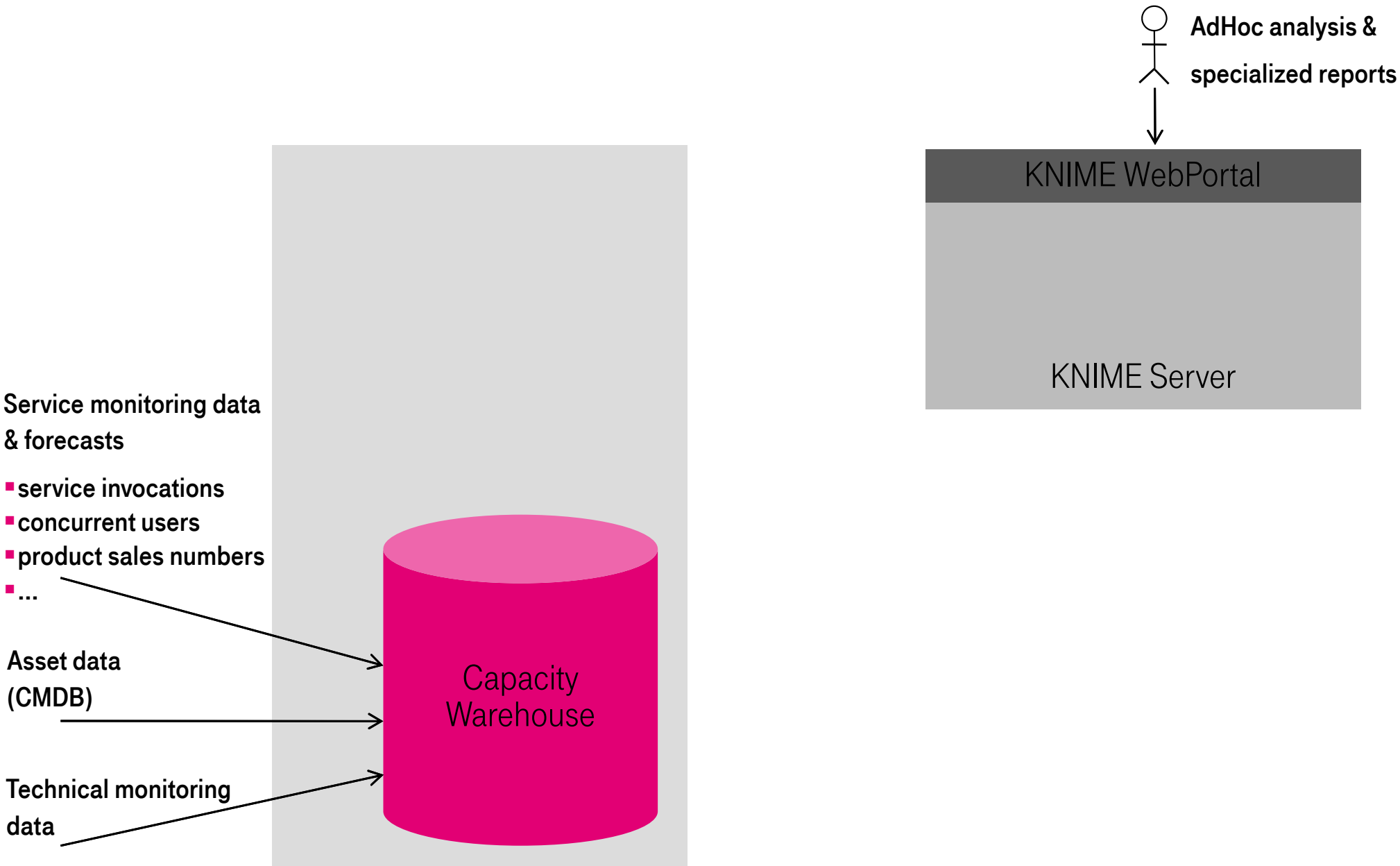

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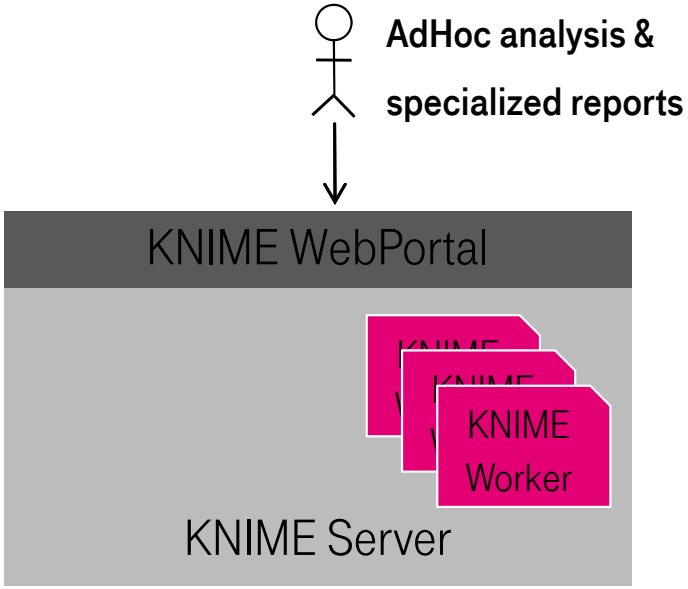
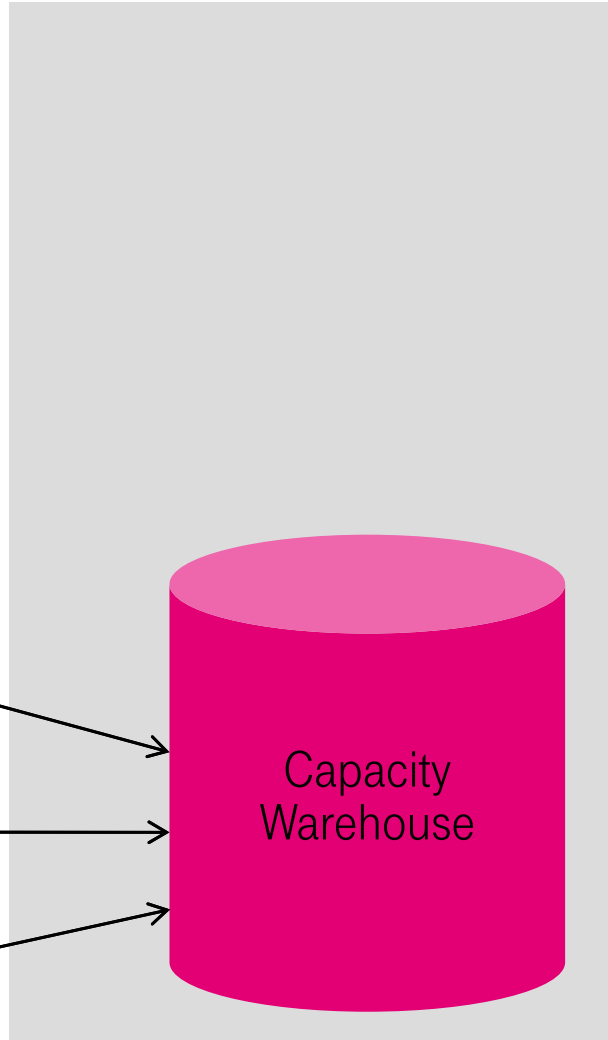


Service monitoring data & forecasts

- service invocations
- concurrent users
- product sales numbers
- ...

Asset data (CMDB)

Technical monitoring data



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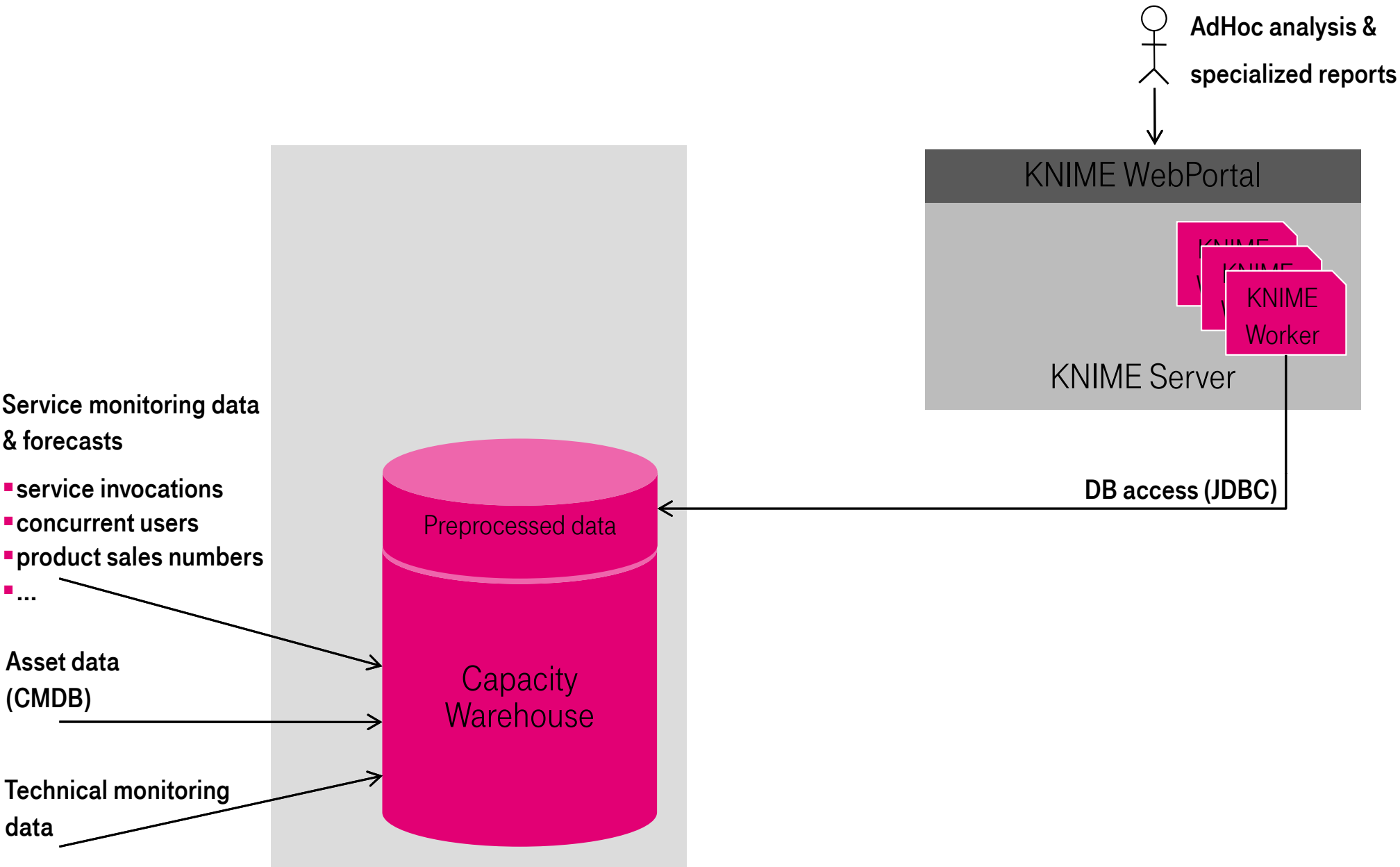

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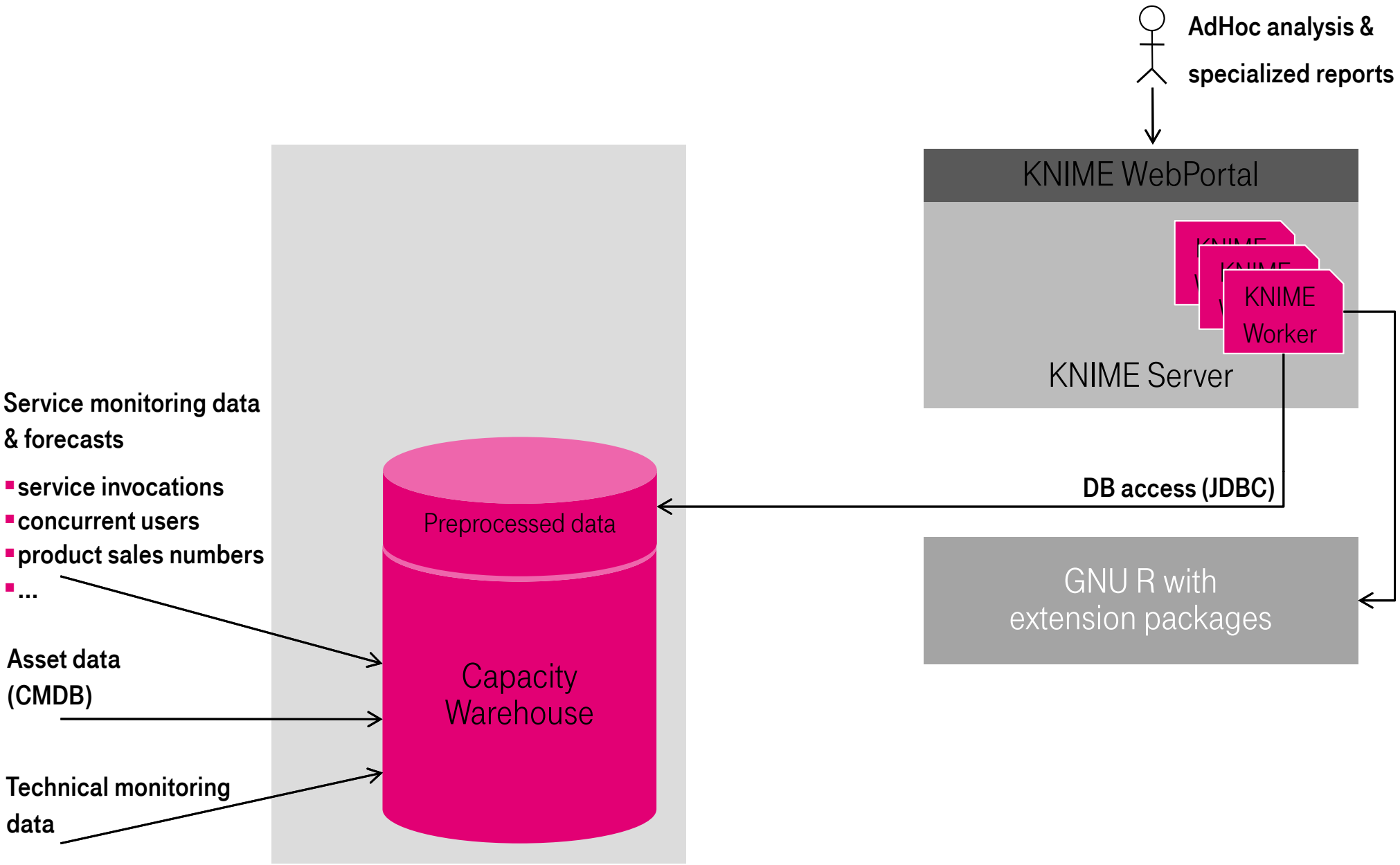

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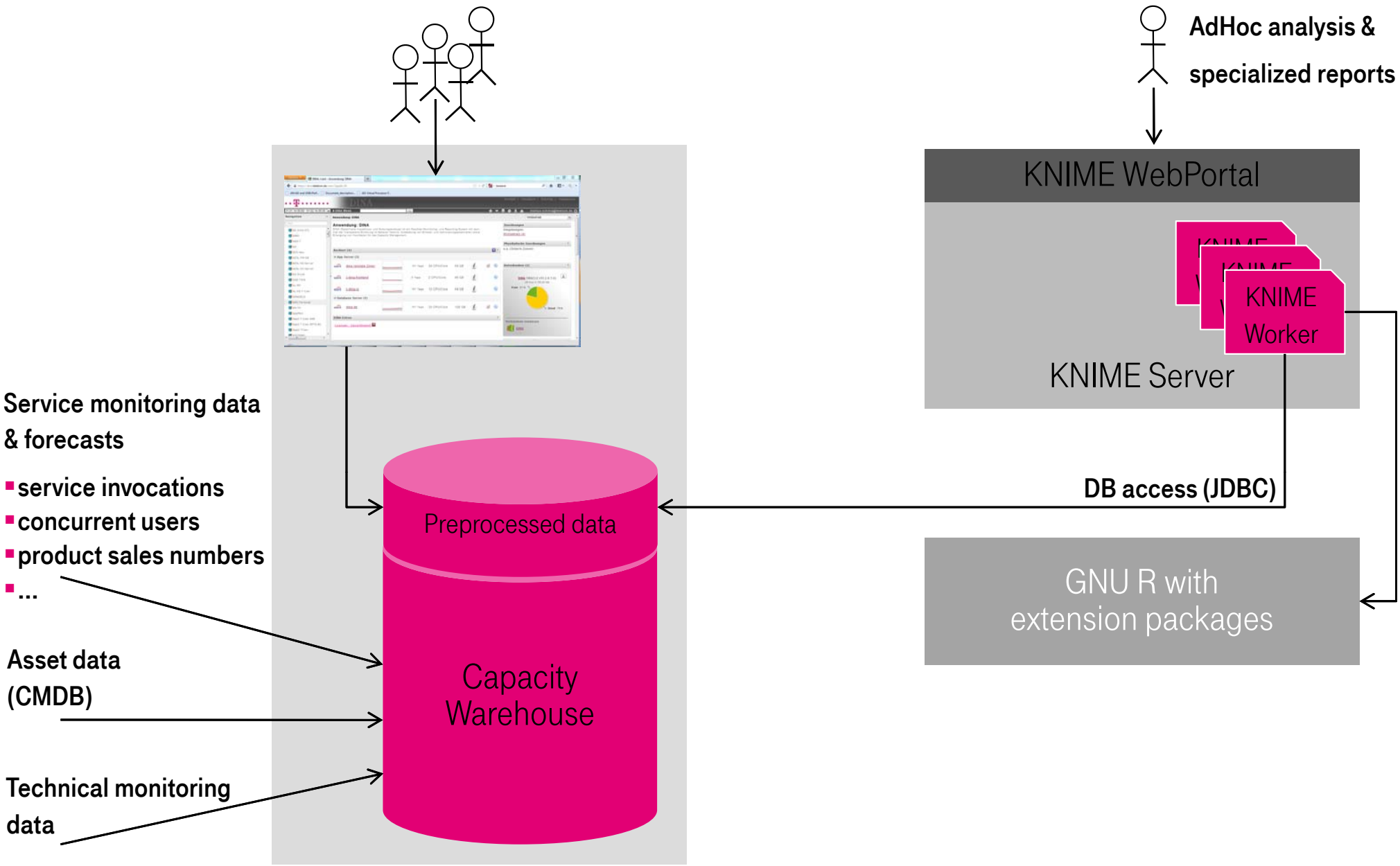

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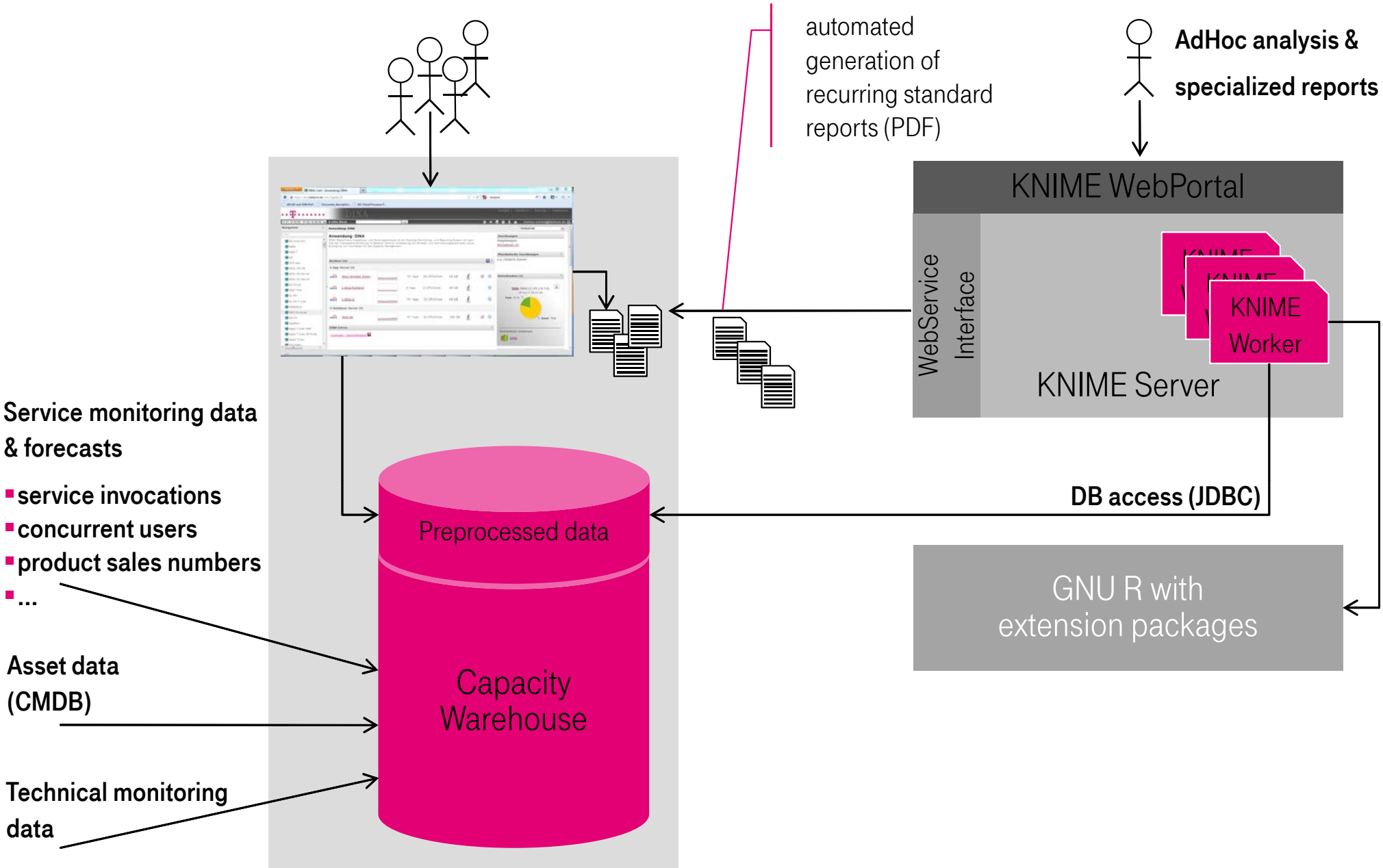

SOME NUMBERS...

Recurring standard capacity reporting (per application)

- About 250 Reports per month
- One PDF-Report per application
  - From 30 to about 250 pages
  - File size between 2 and 25 MB

KNIME JDBC access to capacity warehouse

- Fine-grained data for the last 2-3 years
- Total: about 4.7 TB of data

KNIME workflow for standard report

- Consists of 2.468 nodes (and growing)
- Overhead due to preprocessing and formatting of data, error handling
- Worker Instance uses up to 10GB of main memory

PER APPLICATION OVERVIEW: SERVER CPU-LOAD HEATMAP (MO-FR 08-18:00)

KNIME/BIRT generated page

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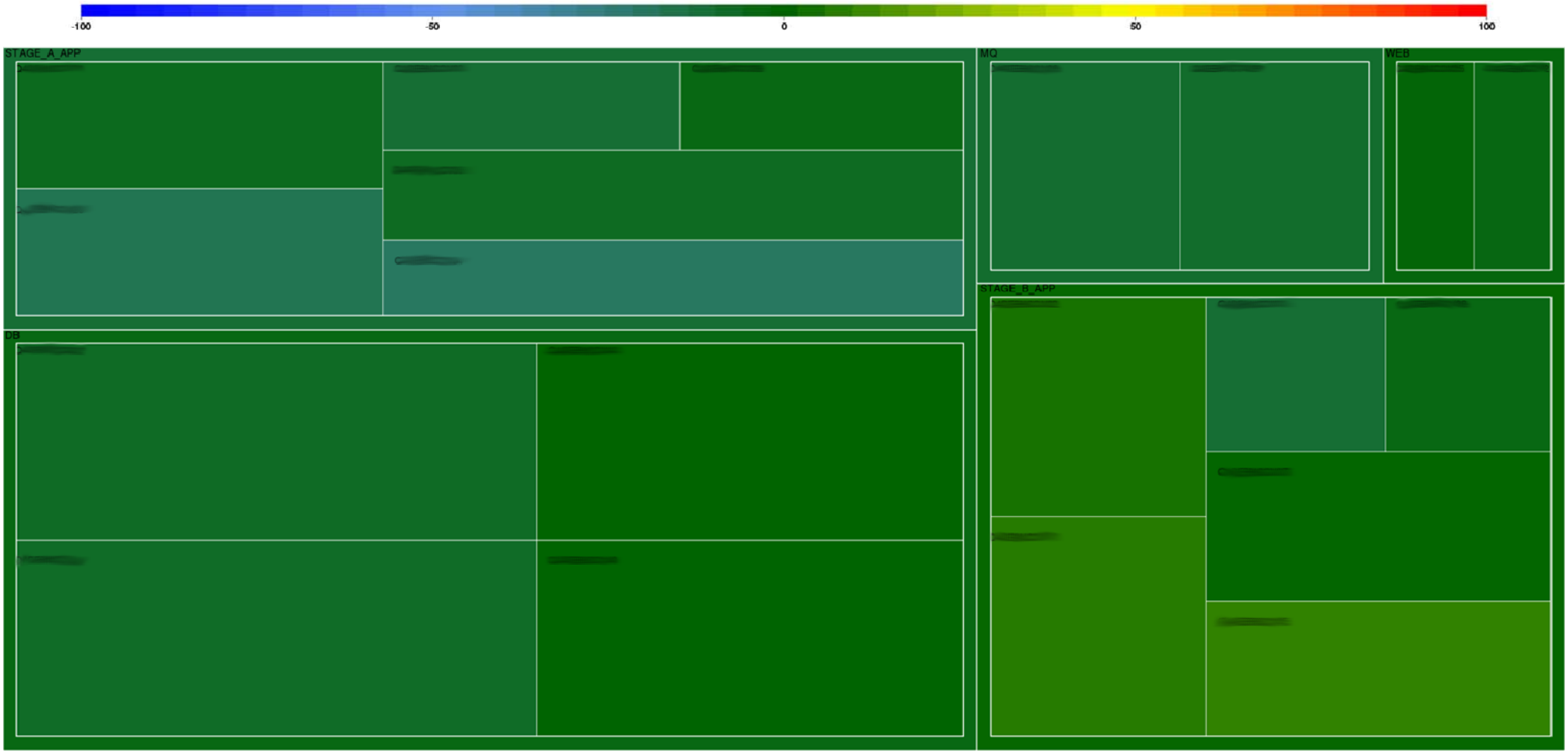

MAX CPU PER DAY (.95 PERCENTILE) (24HRS)

	01.12.13 (Sa)	02.12.13 (Mo)	03.12.13 (Di)	04.12.13 (Mi)	05.12.13 (Do)	06.12.13 (Fr)	07.12.13 (Sa)	08.12.13 (So)	09.12.13 (Mo)	10.12.13 (Di)	11.12.13 (Mi)	12.12.13 (Do)	13.12.13 (Fr)	14.12.13 (Sa)	15.12.13 (So)	16.12.13 (Mo)	17.12.13 (Di)	18.12.13 (Mi)	19.12.13 (Do)	20.12.13 (Fr)	21.12.13 (Sa)	22.12.13 (So)	23.12.13 (Mo)	24.12.13 (Di)	25.12.13 (Mi)	26.12.13 (Do)	27.12.13 (Fr)	28.12.13 (Sa)	29.12.13 (So)	30.12.13 (Mo)	31.12.13 (Di)
SERVER0001	18	7	7	7	8	9	15	18	18	7	7	7	11	11	18	7	7	7	7	7	10	18	6	5	5	5	5	15	19	6	5
SERVER0002	14	51	45	44	50	38	11	15	45	50	48	40	38	17	13	43	44	43	43	36	13	13	35	11	6	4	18	12	13	24	14
SERVER0003	16	5	2	3	3	6	9	15	10	11	10	2	9	8	15	13	2	3	2	2	9	15	6	2	2	2	5	10	15	5	2
SERVER0004	15	48	43	42	44	37	10	15	39	43	47	35	33	14	15	40	42	38	42	35	9	15	32	10	5	4	17	11	17	22	9
SERVER0005	2	0	0	0	0	1	1	2	1	0	1	0	0	1	2	1	1	0	1	0	1	2	1	1	0	0	0	1	2	1	0
SERVER0006	28	84	83	84	88	77	28	20	80	81	76	80	82	32	23	85	81	84	85	79	26	15	64	32	14	9	60	30	15	65	48
SERVER0007	2	1	1	0	0	1	1	2	1	2	2	0	1	1	2	1	1	1	1	1	2	2	1	1	0	0	1	2	2	1	1
SERVER0008	15	41	47	59	51	50	54	35	49	54	51	55	51	56	47	46	48	51	54	58	54	15	53	47	14	12	45	23	16	56	51
SERVER0009	35	83	94	17	95	38	28	34	34	18	88	18	27	28	35	93	67	18	66	24	32	34	93	15	14	14	21	28	34	88	15
SERVER0010	1	0	0	0	0	0	1	1	0	0	0	0	0	2	1	1	0	0	0	0	1	1	0	0	0	0	0	1	1	0	0
SERVER0011	32	85	83	86	85	82	32	22	82	80	79	79	83	39	24	86	84	86	86	83	33	19	68	37	20	11	65	38	20	72	59
SERVER0012	1	1	0	0	0	1	1	1	1	0	0	0	1	2	1	1	1	0	0	0	1	1	0	1	0	0	1	2	1	1	0
SERVER0013	19	40	44	54	49	47	49	27	46	50	47	50	50	48	43	39	43	46	51	58	50	20	46	40	16	15	39	19	18	53	44
SERVER0014	58	40	56	79	74	48	40	58	51	61	69	60	46	46	57	44	38	70	60	49	47	58	35	34	42	28	39	44	58	43	36
SERVER0015	76	77	81	78	81	75	78	60	79	76	79	79	78	84	64	81	77	82	73	72	64	63	64	57	52	48	78	80	61	64	58
SERVER0016	11	16	18	14	14	16	52	10	15	14	15	19	19	43	13	20	51	18	15	14	56	11	14	12	5	6	17	47	10	18	13
SERVER0017	52	25	28	30	29	29	35	42	22	27	29	28	28	36	41	30	41	42	28	29	29	42	24	25	21	22	23	32	43	24	21
SERVER0018	91	87	88	87	86	85	85	91	87	86	88	89	87	88	92	87	89	87	89	86	88	92	86	88	83	82	85	86	91	91	88

Max. CPU Usage
(.95 percentile)

- no data
- 0-10 %
- 10-20 %
- 20-30 %
- 30-40 %
- 40-50 %
- 50-60 %
- 60-70 %
- 70-80 %
- 80-90 %
- 90-100 %

TECHNICAL CAPACITY RATING - OVERVIEW

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			CPU		Memory / Swap		Storage		I/O	
	Host	Component	Rating	Trend	Rating	Trend	Rating	Trend	Rating	Trend
	SERVER0001	Web Server	31	→	31	→		↗		
	SERVER0002	MQ	18	→	20	→		↗		
	SERVER0003	Web Server	31	→	31	→		↗		
	SERVER0004	MQ	17	→	29	→		↗		
	SERVER0005	Stage A AppSrv	31	→	31	→		↗		
	SERVER0006	Stage B AppSrv	24	→	3	↗		↘		
	SERVER0007	Stage A AppSrv	31	→	31	→		↗		
	SERVER0008	Stage B AppSrv	31	→	31	→		↗		
	SERVER0009	Stage A AppSrv, Stage B AppSrv	29	→	31	→		↗		
	SERVER0010	Stage A AppSrv	31	→	31	→		↘		
	SERVER0011	Stage B AppSrv	24	→	31	↗		↘		
	SERVER0012	Stage A AppSrv	31	→	31	→		↘		
	SERVER0013	Stage B AppSrv	31	→	31	→		↗		
	SERVER0014	Stage A AppSrv, Stage B AppSrv	29	→	31	→		↗		
	SERVER0015	Database Server	31	→	31	→		↘		
	SERVER0016	Database Server	3	→	31	→		↗		

SERVER0014 : CPU LOAD

29

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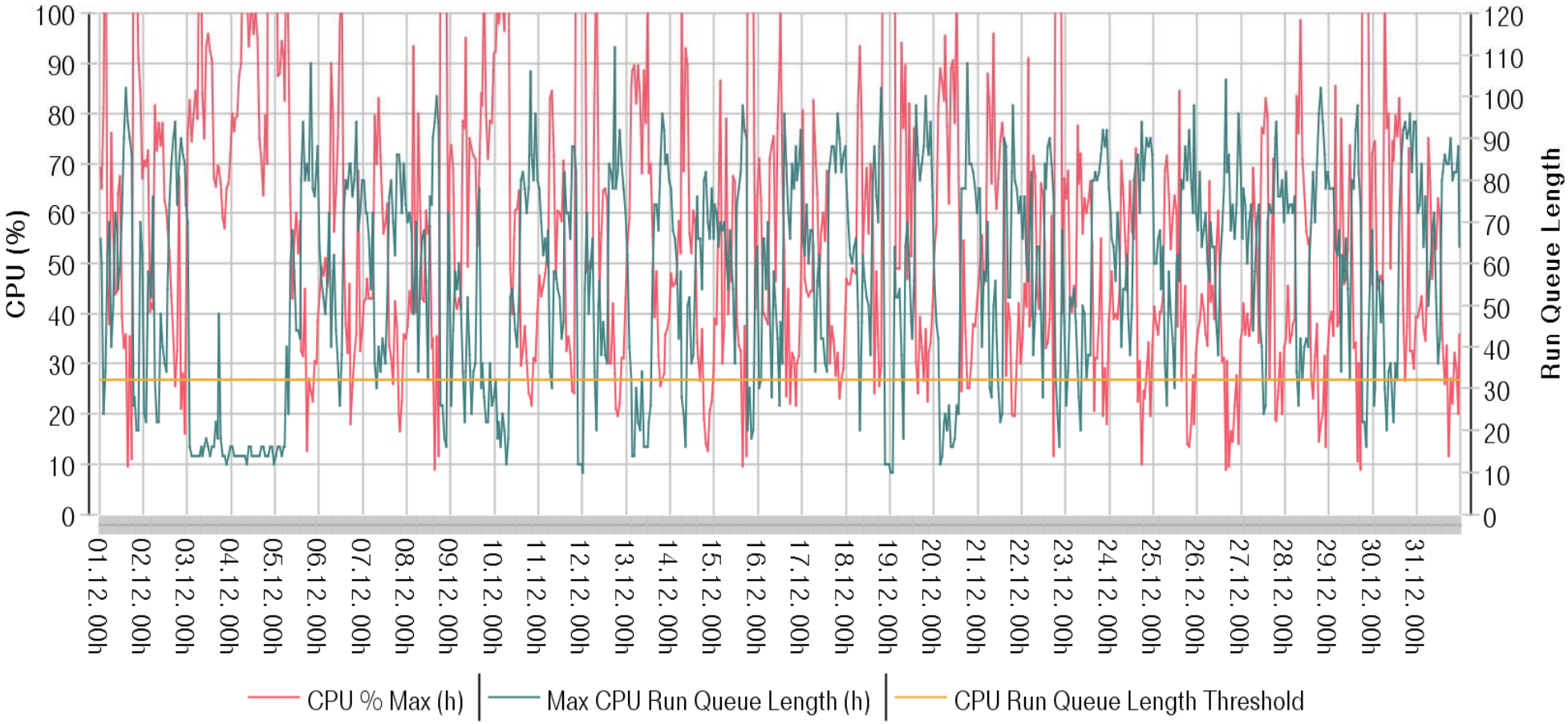
AIX 6 1, IBM,9179-MHC PowerPC_POWER7



Reason: (RunQueue > Threshold) > 119 Min. (for 29 days)

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SERVER0014: FILE SYSTEMS

File system	Reason	Min free		Rating	
10.175.36.207:/opt/WebSphere/install_sourcen, 52 G		3 G		31	
/dev/chrootlv, 41 G		11 G		29	
/dev/optwebs4, 41 G		23 G		31	
/dev/varwebs4, 27 G	Allocated space is constantly below 20% and growth rate is near 0 (31 days)	25 G		31	
/dev/exportlv, 21 G		8 G		31	
/dev/cognoslv, 11 G		3 G		31	
/dev/optoralv, 11 G		2 G		31	
/dev/hd2, 6 G		0 G		31	
/dev/tqslv, 4 G	Allocated space is constantly below 20% and growth rate is near 0 (31 days)	2 G		31	
/dev/ITM6_lv, 3 G	Allocated space is constantly below 20% and growth rate is near 0 (31 days)	1 G		31	
/dev/hd10opt, 3 G		1 G		31	
/dev/openv_lv, 3 G		1 G		31	
/dev/hd4, 2 G		1 G		31	
/dev/hd3, 2 G	Number of days < 30 until filesystem reaches 100% capacity (8 days)	0 G		18	
/dev/hd1, 2 G		0 G		31	
/dev/hd9var, 2 G		0 G		31	

BUSINESS DATA CONTROL CHART
SERVICE_X: TREND OF SERVICE INVOCATIONS PER DAY

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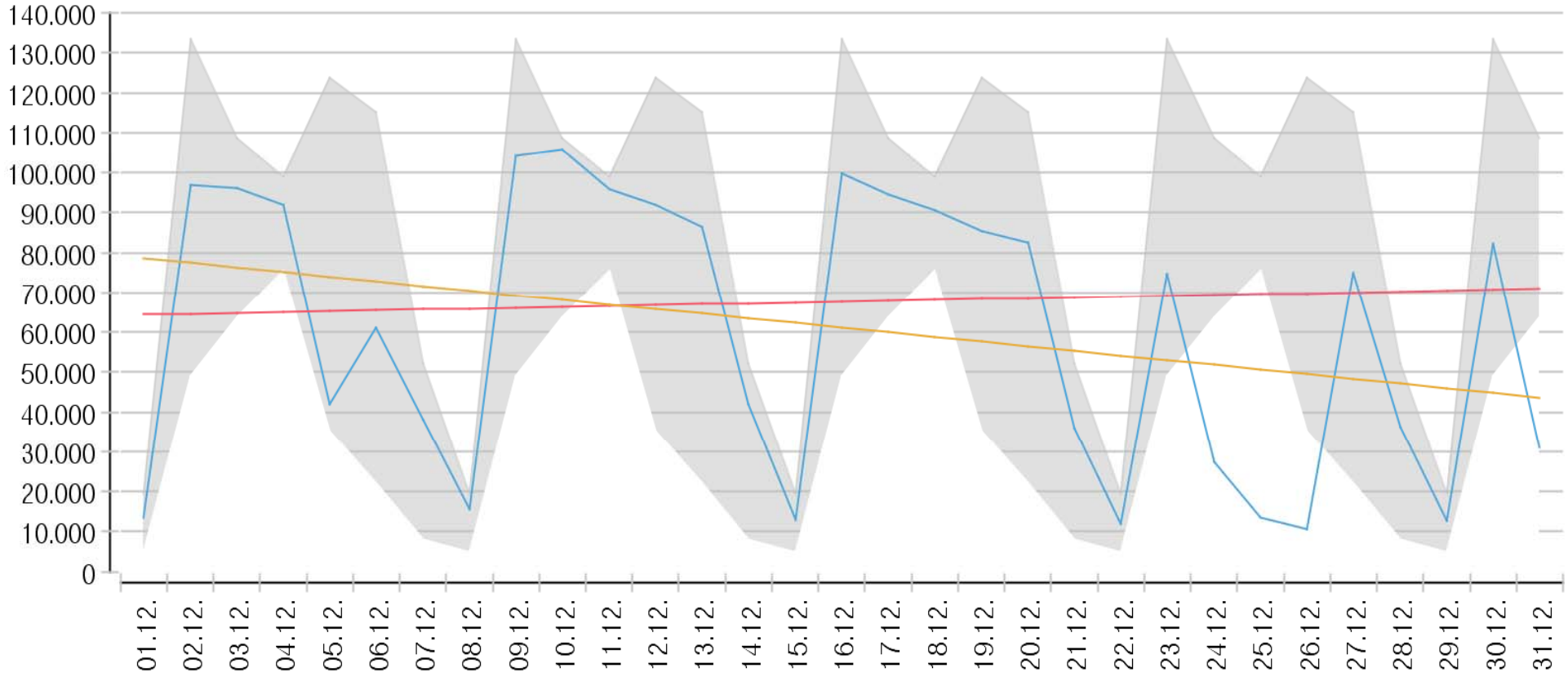

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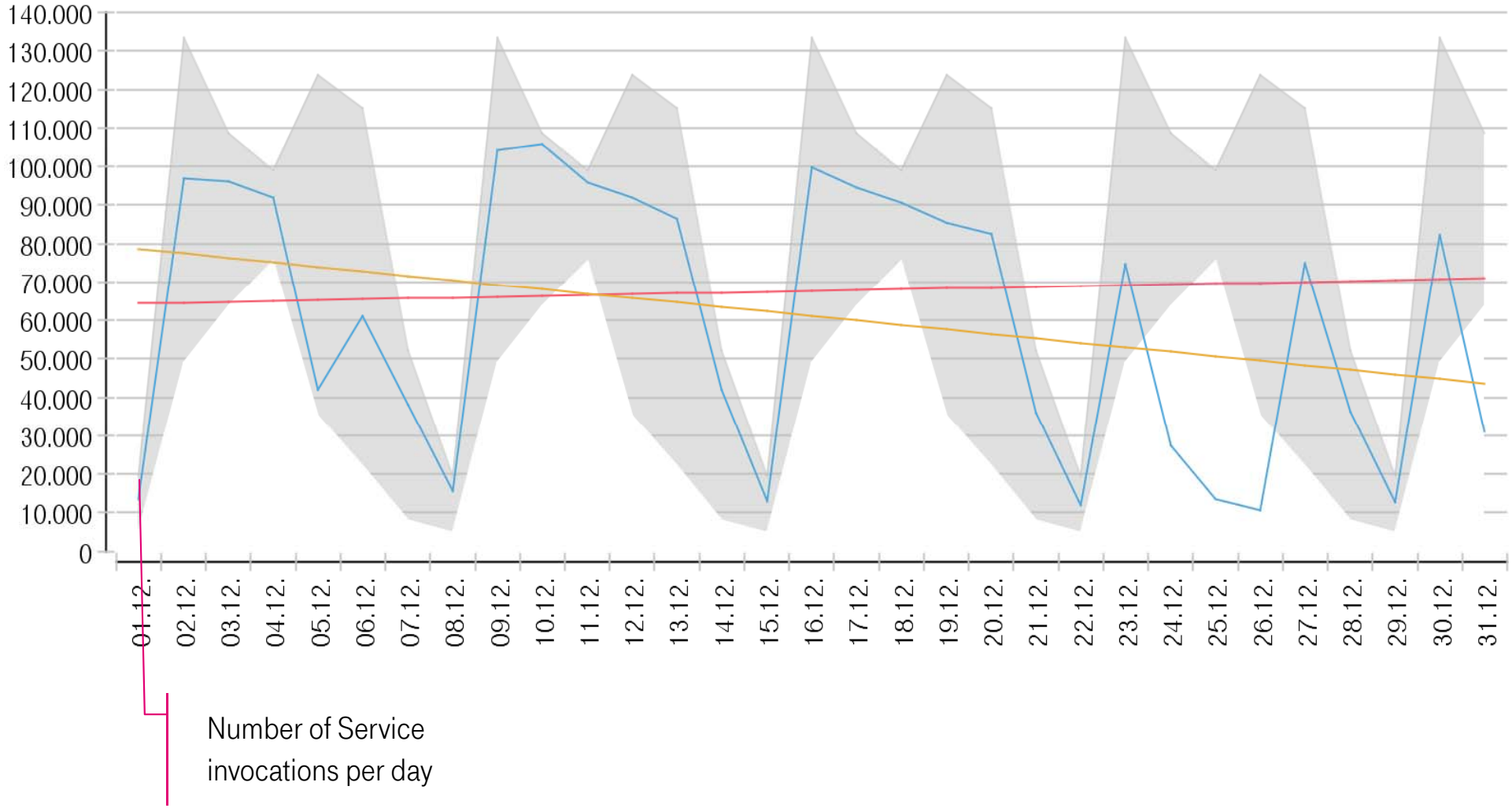

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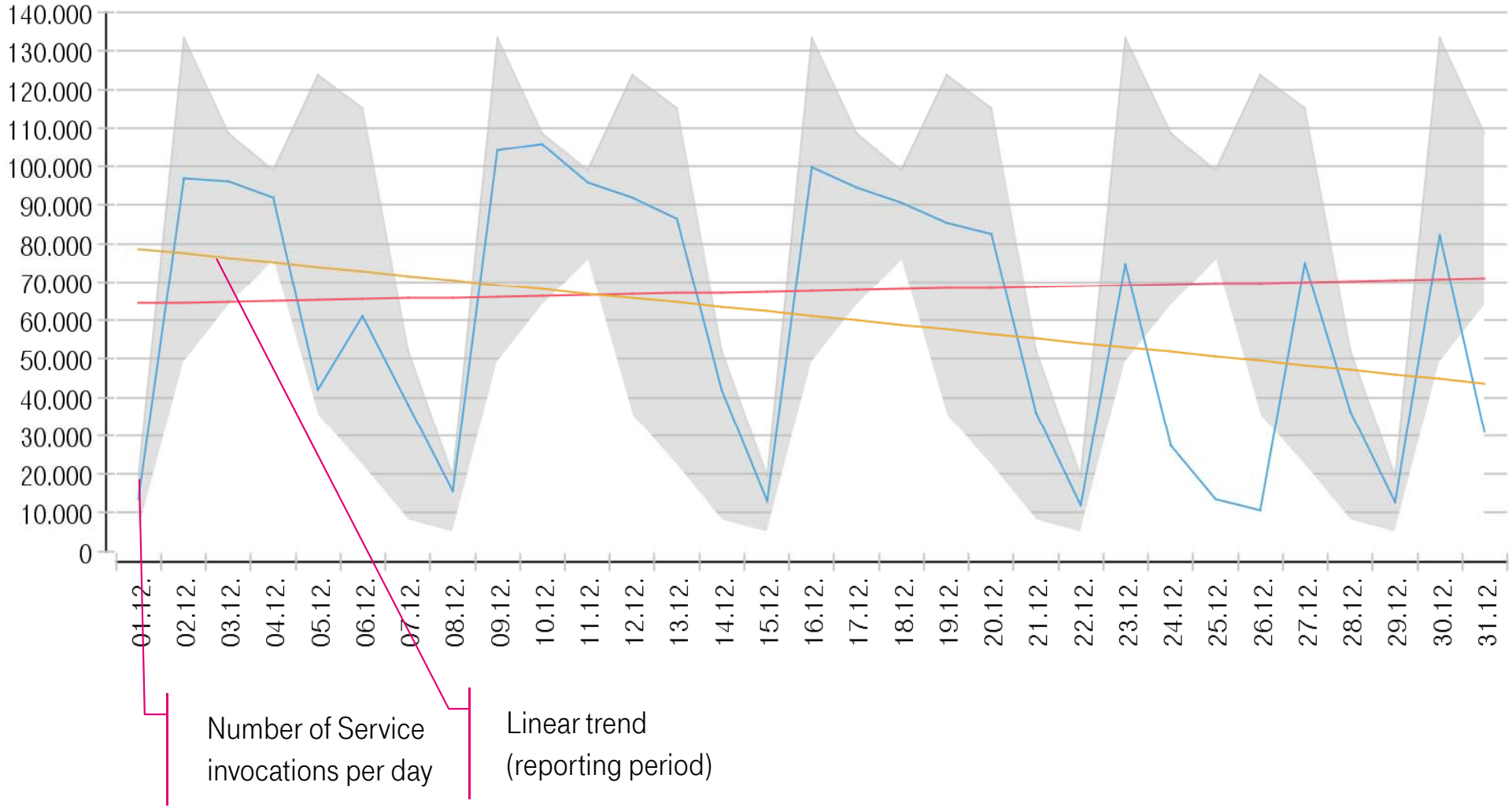

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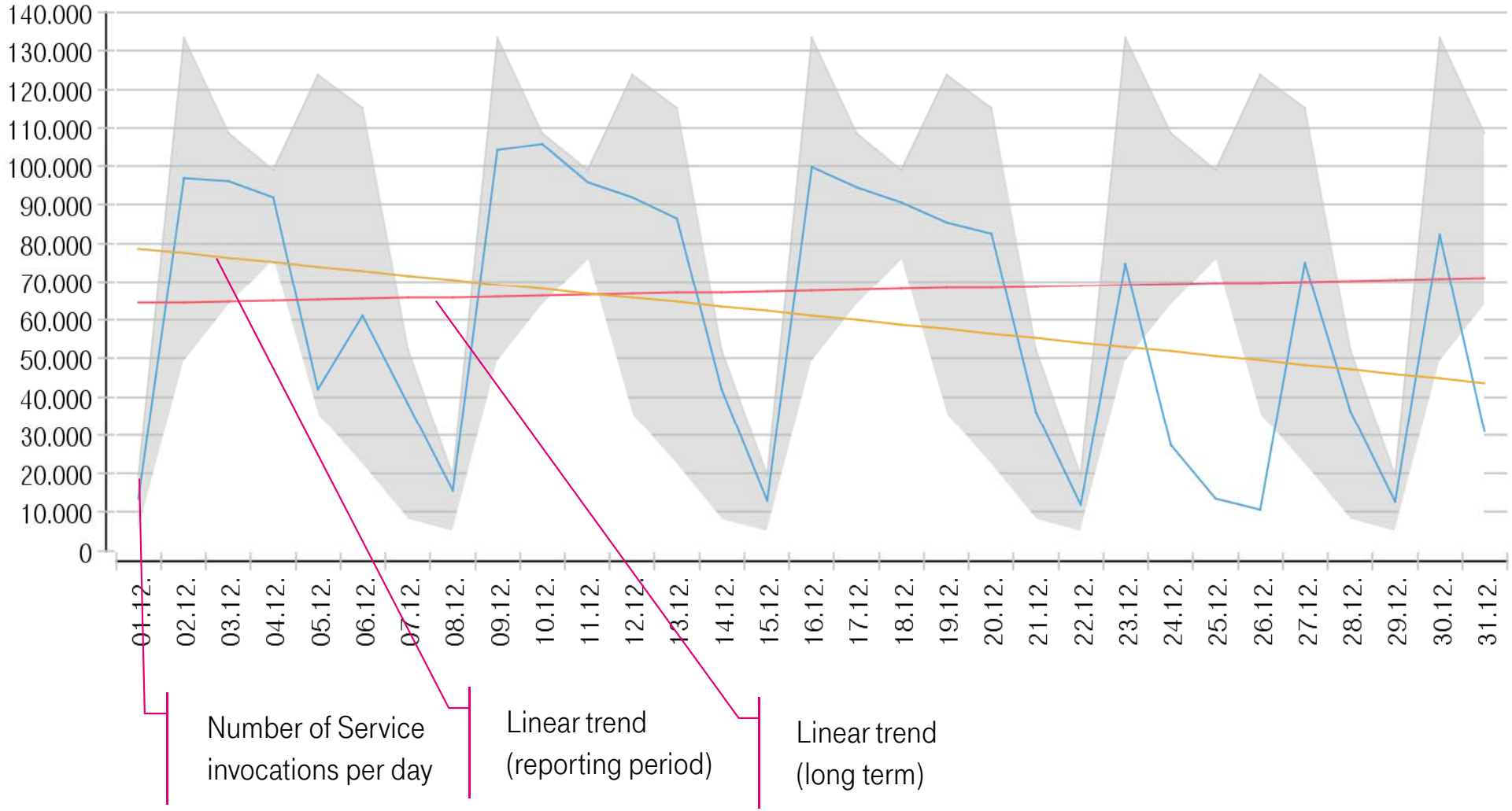

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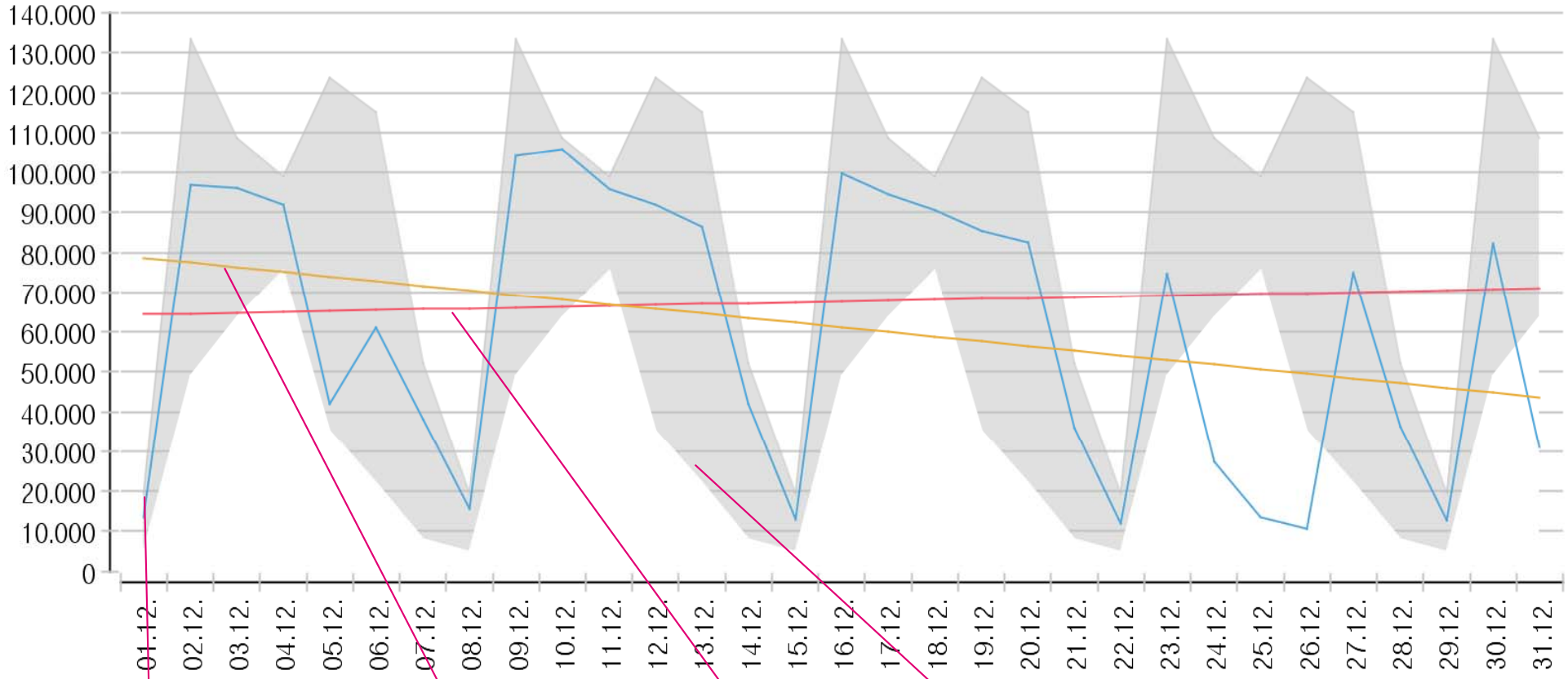

Number of Service invocations per day

Linear trend (reporting period)

Linear trend (long term)

Average number of historical service invocations per day of week +/- 3x std. deviation

BUSINESS DATA CONTROL CHART
SERVICE_X: TREND OF SERVICE INVOCATIONS PER DAY

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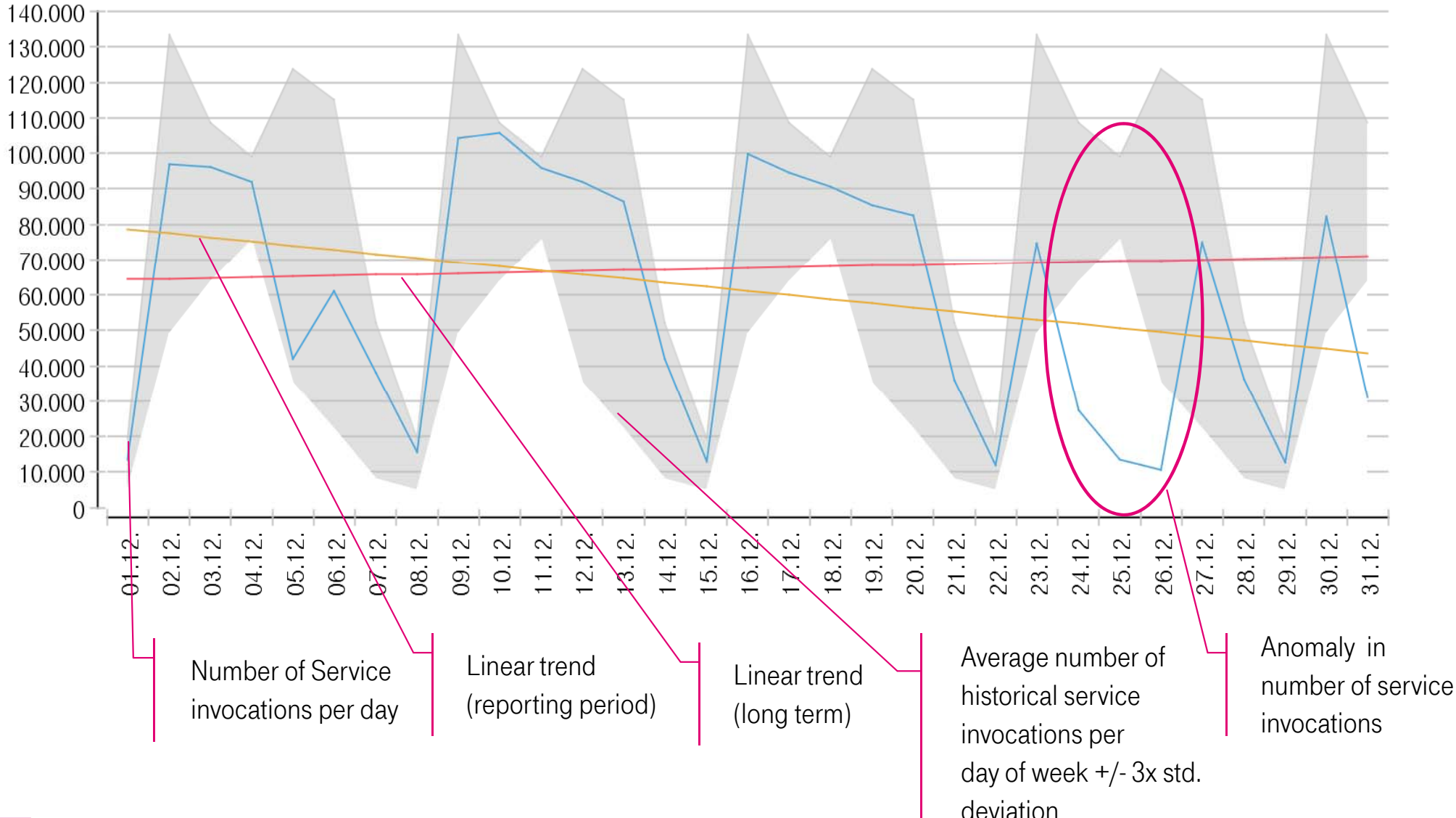


MAPPING BUSINESS DATA TO INFRASTRUCTURE

Challenges:

- Constantly changing, large-scale environment:
  Use of fine-grained modeling techniques is not adequate
- Point of measurement for business data often unknown
  - Possibly delay in measurements, unknown impact on quality, ...
  - Mapping to IT infrastructure is challenging

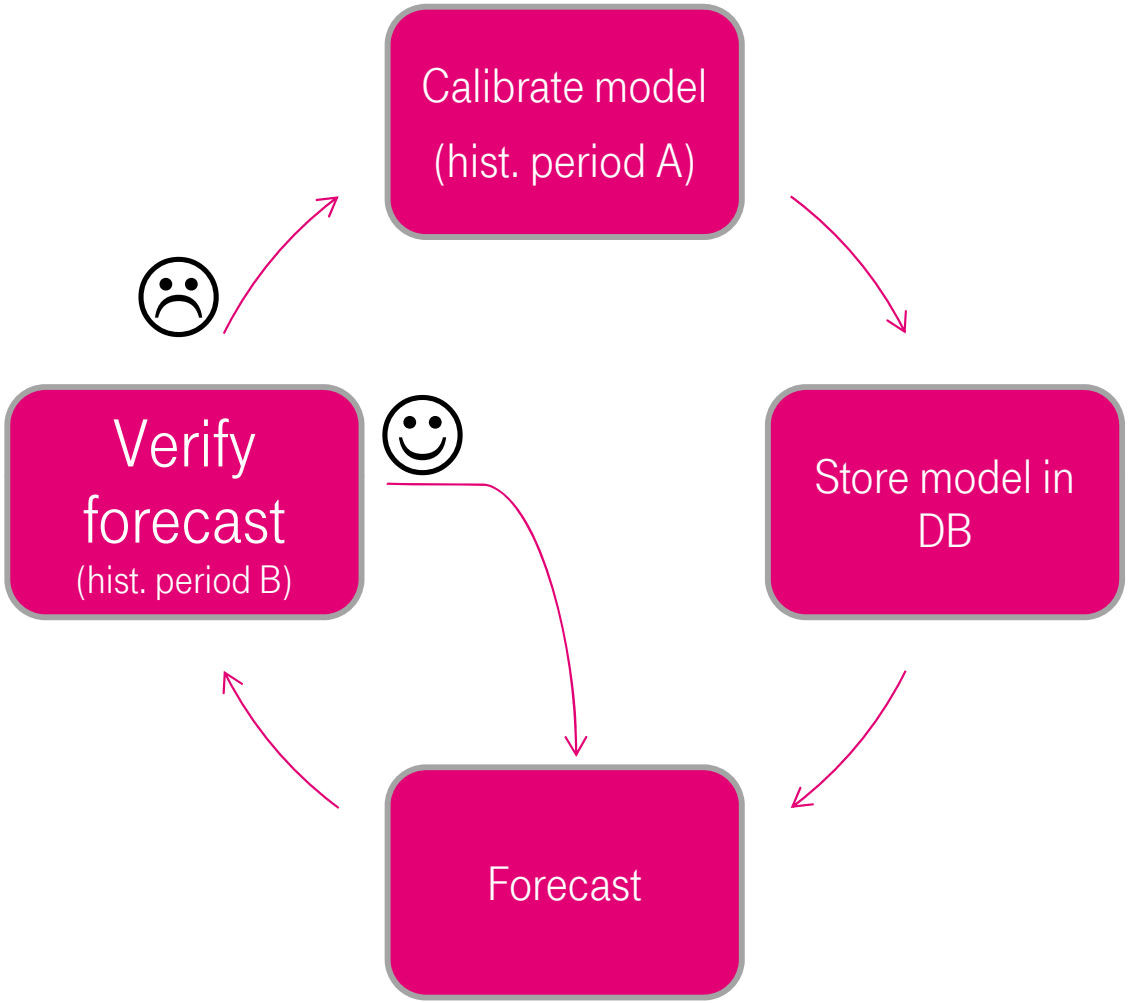
Determine correlation between historical business data and technical monitoring data (e.g. CPU load)

- Multi-step process:
  - Mapping of business data to technical metrics (e.g. service calls)
  - Mapping of service calls to resource load
- Resource mapping based on CMDB asset data
- Complexity: Quality of data source, granularity of data; resources may be active or inactive, changes in resource capacity, ...
- Make sure, that all relevant load factors have been taken into account

Use regression techniques to forecast infrastructure load based on business forecast

- Possibly use historical information (e.g. on forecast quality) to improve predictions

FORECASTING OF RESOURCE LOAD



BUSINESS DATA / CPU LOAD: STATISTICAL ANALYSIS

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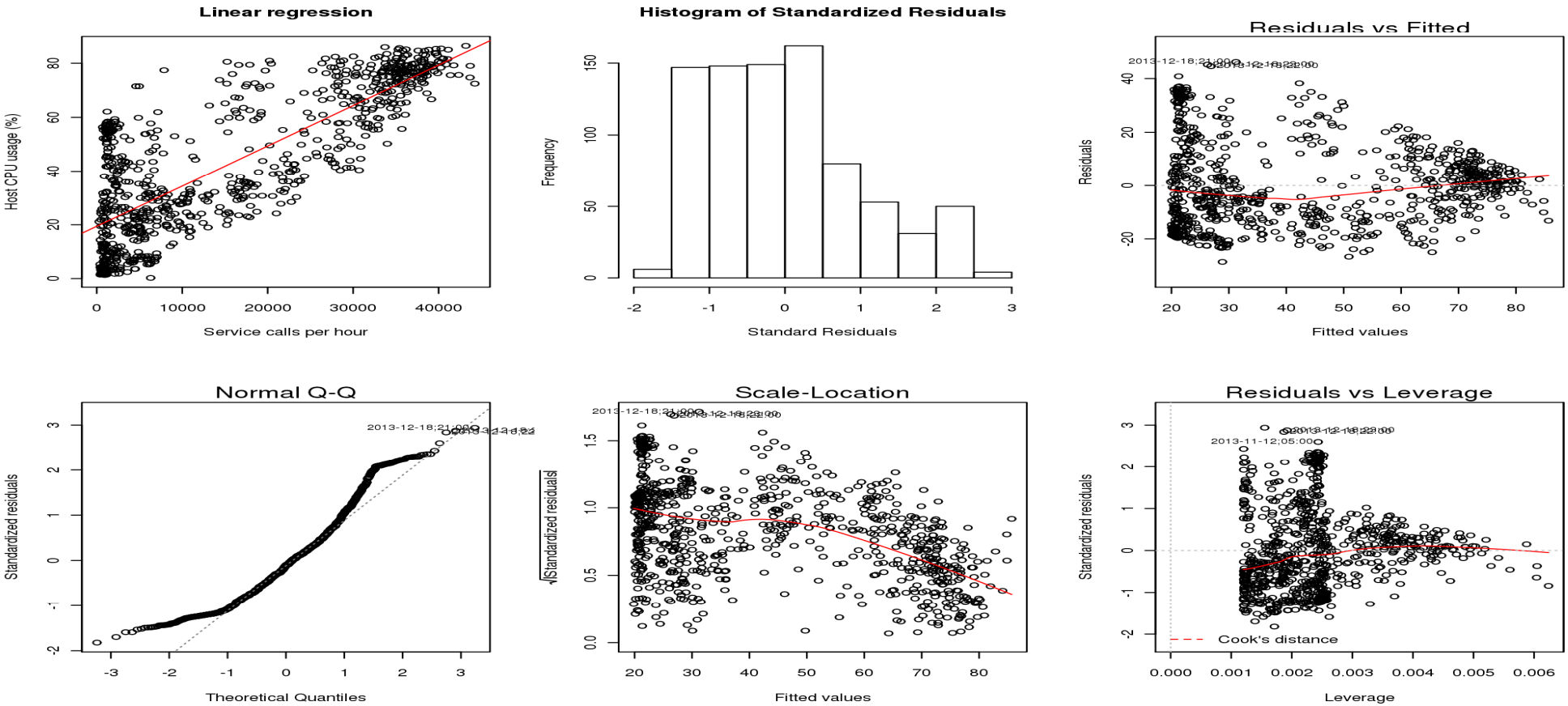

Intercept						Slope						Statistics
Estimate	StdErr	95% LCL	95% UCL	t	Pr(>|t|)	Estimate	StdErr	95% LCL	95% UCL	t	Pr(>|t|)	adj. COD
19,442	0,8104	17,8514	21,0326	23,9918	0	0,0015	0	0,0014	0,0016	38,625	0	0,6427

VISUALISATION OF CORRELATION BETWEEN REFERENCE SERVICES AND OTHER SERVICES

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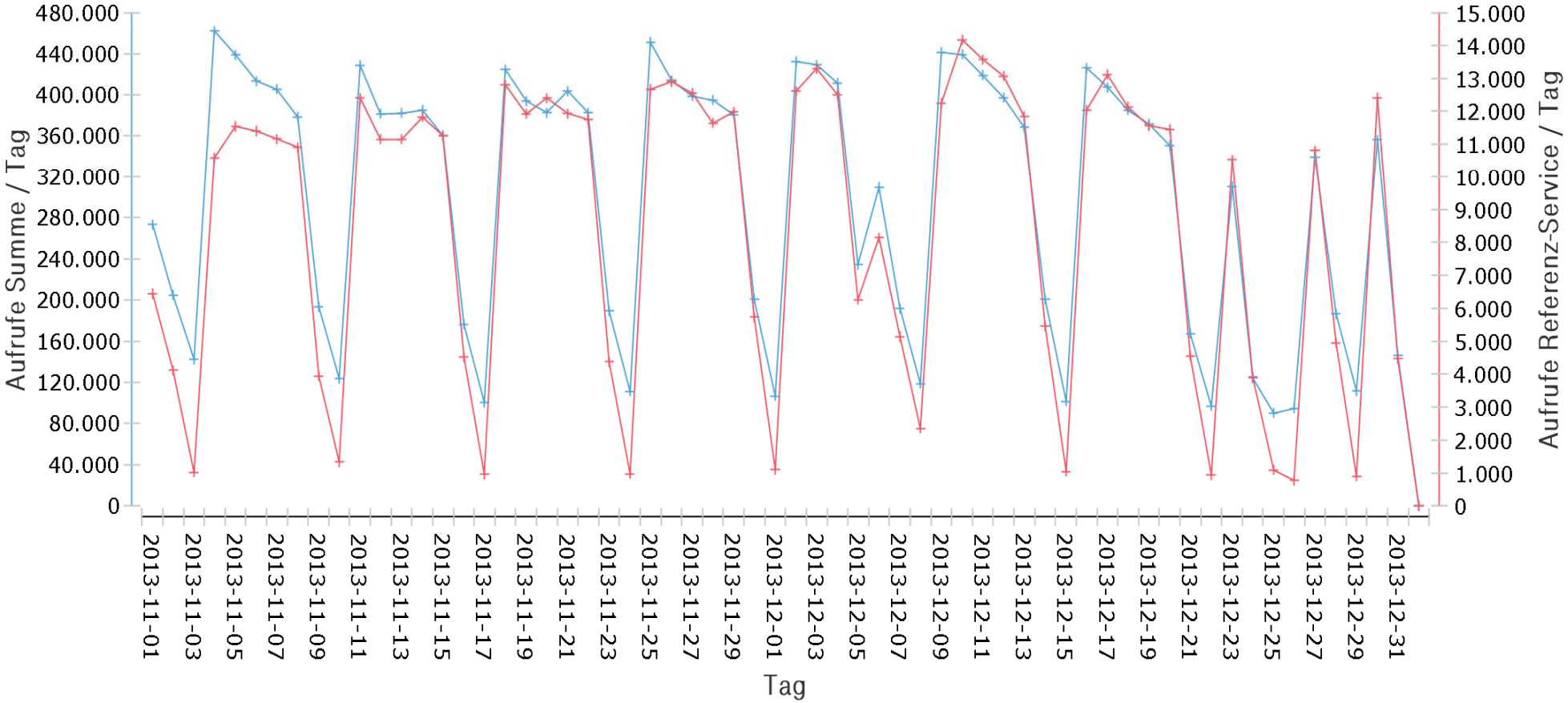

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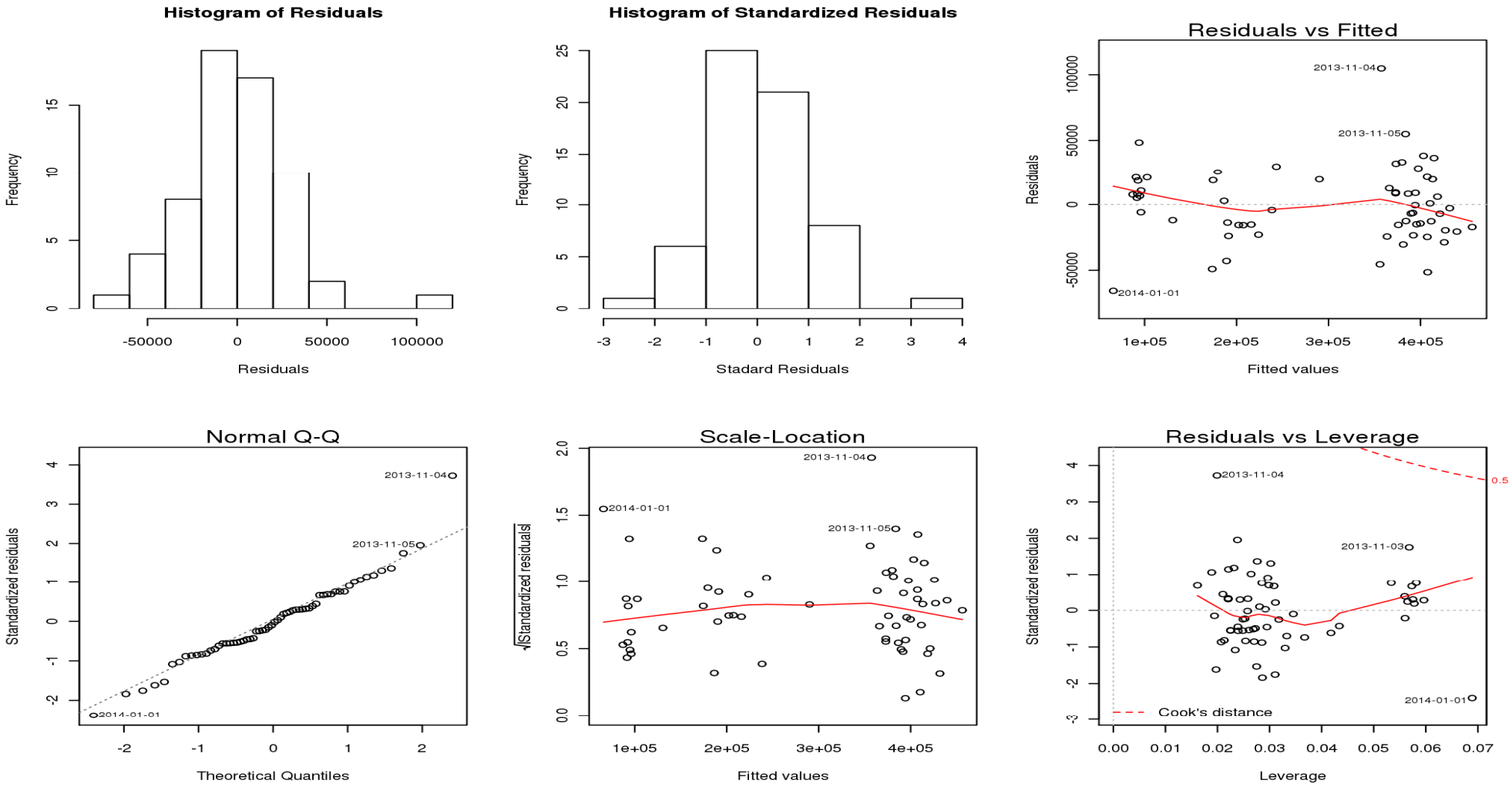

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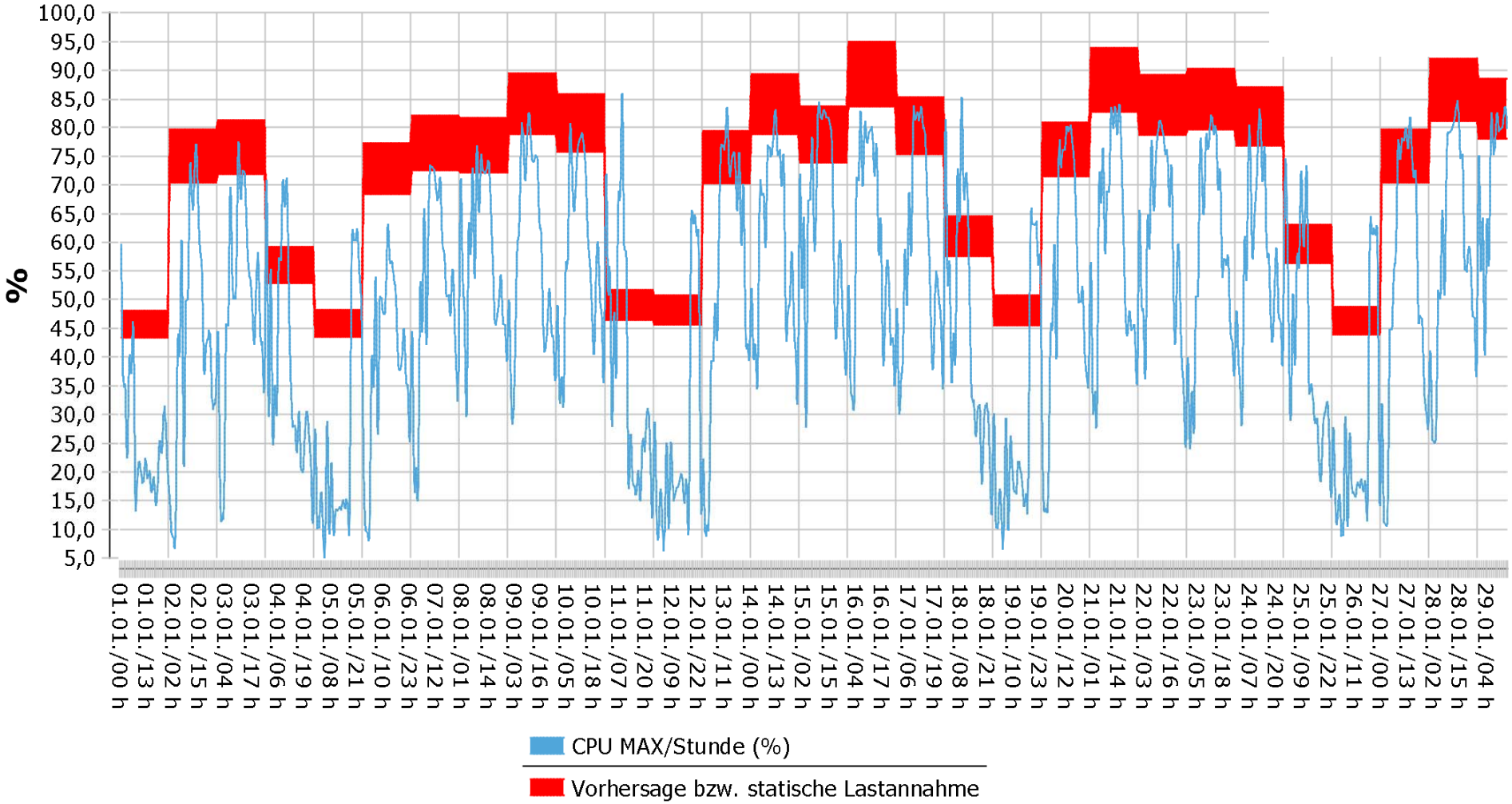
VERIFICATION OF CPU FORECAST: SERVER_A



Prognose auf Basis Modell-Kalibrierungszeitraum 01.11.2013 bis 31.12.2013

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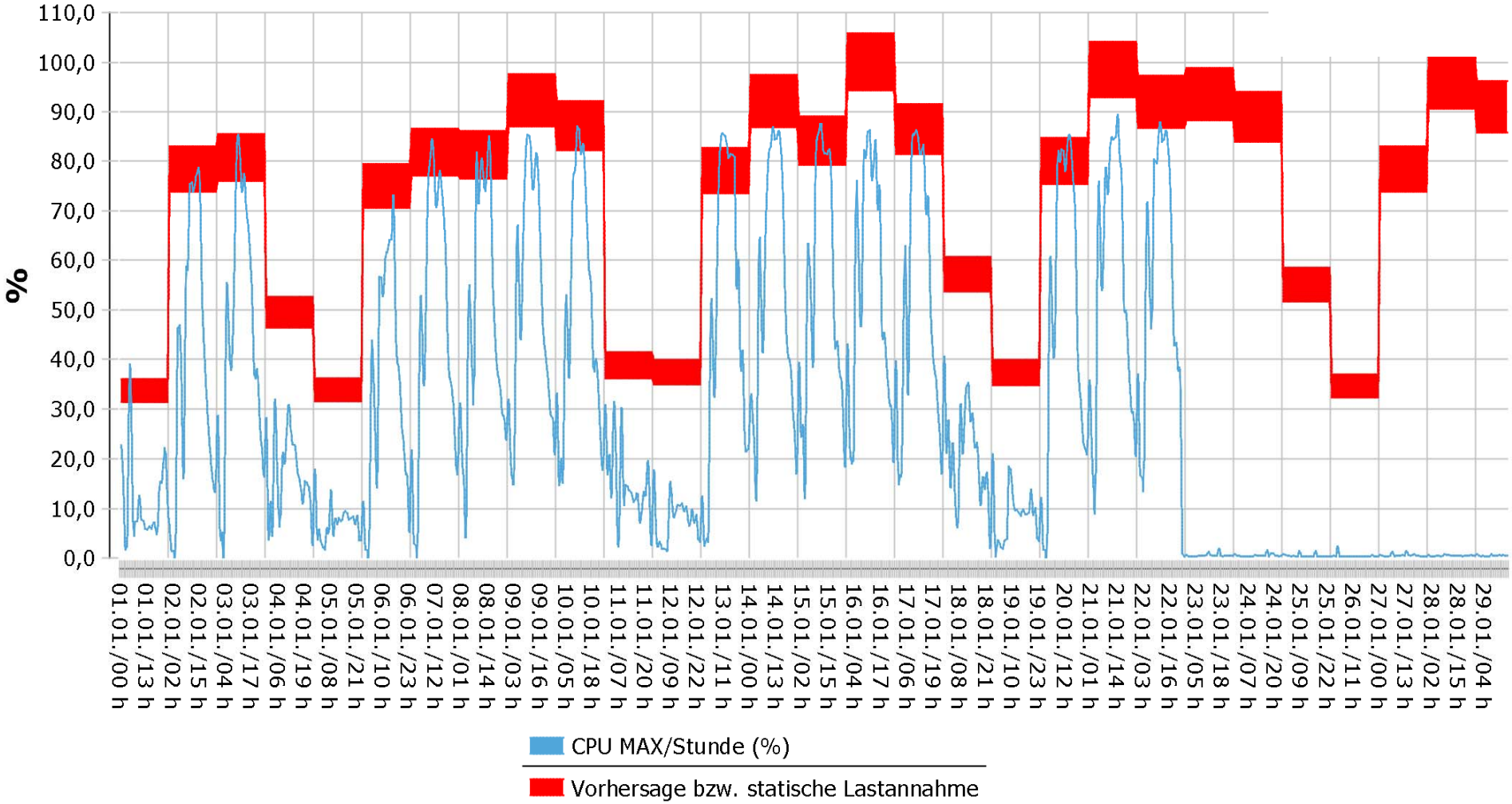
VERIFICATION OF CPU FORECAST: SERVER_B



Prognose auf Basis Modell-Kalibrierungszeitraum 01.11.2013 bis 31.12.2013

LESSONS LEARNED: LARGE SCALE WORKFLOW DESIGN

KNIME/BIRT + R is a powerful tool combination for statistical data analysis and graphical presentation

Processing of large data sets is easily possible

While KNIME scales well across multiple CPUs, BIRT only uses a single core

KNIME allows easy transition from ad-hoc analysis to provisioning of automated, recurring tasks

Designing and testing of large workflows is a complex task

- In-workflow documentation of functionality is essential!
- Use a proper build chain with development, testing and production environment (Also helpful for testing upgrades)

LESSONS LEARNED: LARGE SCALE WORKFLOW DESIGN (2)

Always make sure, your input data is stored with the correct column type (int vs. double problem)

- If unsure, enforce conversion before loop-ends and after invocation of R nodes

Document your column types, names and order of data to report nodes and make sure, they don't change (Otherwise BIRT may silently delete some of your scripts)

If things start to slow down: Check the heap memory requirements of your workflows

- 75%-Threshold on Pool "PS Old Gen" causes GC

Server-based execution stops on some errors you don't notice when testing in KNIME desktop (e.g. unconnected nodes):

- Check the logs
- ..., but debugging is still hard with thousands of nodes

Decrease the debug-level in production: this significantly speeds things up

Thank you...

Any Questions?

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