

SAP HANA streaming analytics

January 2020

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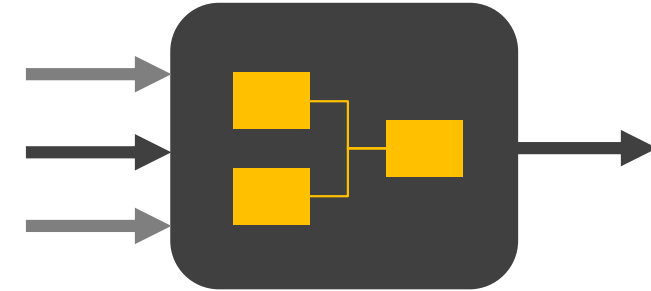
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SAP HANA streaming analytics

extends the capabilities of HANA to analyze and act on data in motion

Continuous Intelligence with Streaming Analytics:

- insight from live event streams
- instantaneous response



Process live event streams

- ✓ Process events in real-time, as fast as they arrive
- ✓ Filter, enrich, transform, normalize
- ✓ Capture high value data in SAP HANA

Analyze data in motion

- ✓ Analyze events in the context of other events and historical data
- ✓ Watch for patterns, trends, correlations
- ✓ Apply predictive analytics to anticipate what's coming
- ✓ Apply rules to determine what action to take

Act in Real-time

- ✓ Directly impact continuous business processes
- ✓ Alerts – while there is time to act
- ✓ Immediate response
- ✓ Continuous computation of KPI's
- ✓ Stream key data to live dashboards

SAP rated a “Leader” in The Forrester Wave™: Streaming Analytics, Q3 2017

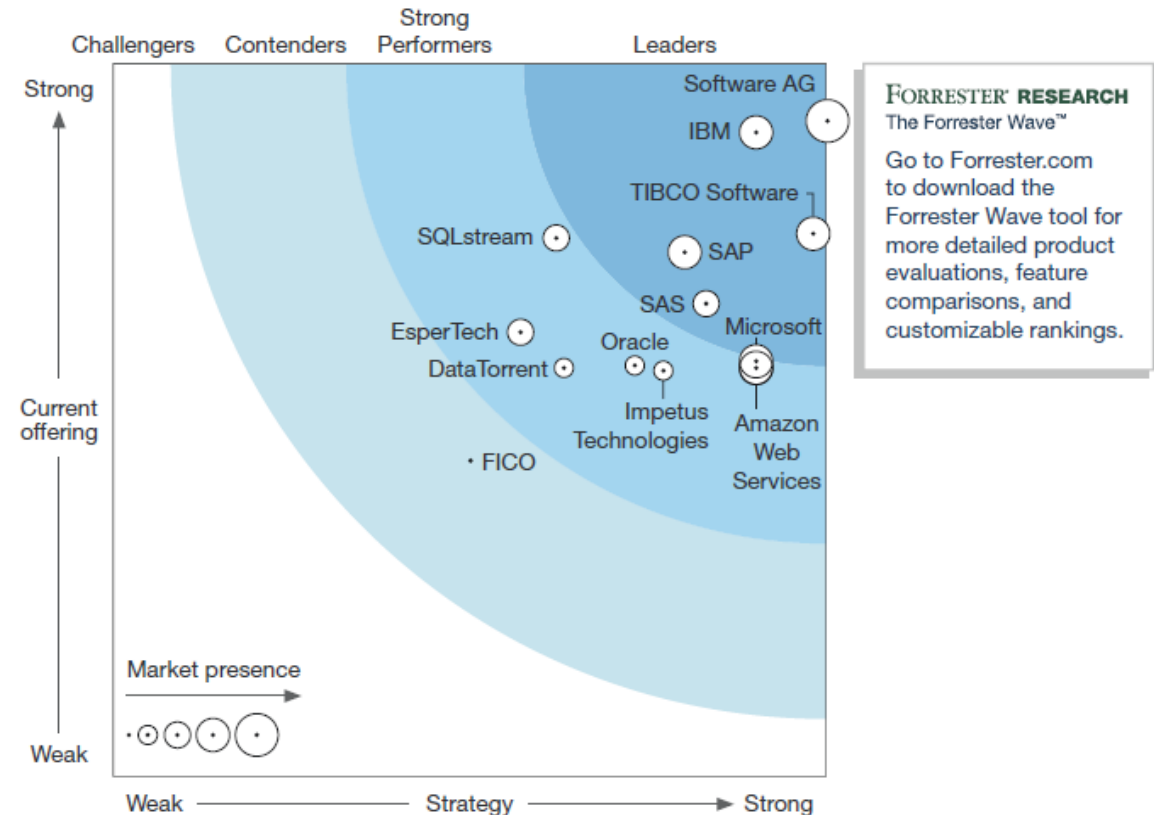
“Streaming analytics is essential for bringing real-time context to apps.”

- Forrester

Forrester defines streaming analytics as:

Software that can filter, aggregate, enrich, and analyze a high throughput of data from multiple, disparate live data sources and in any data format to identify simple and complex patterns to provide applications with context to detect opportune situations, automate immediate actions, and dynamically adapt.

FIGURE 4 Forrester Wave™: Streaming Analytics, Q3 '17



FORRESTER RESEARCH
The Forrester Wave™
Go to Forrester.com to download the Forrester Wave tool for more detailed product evaluations, feature comparisons, and customizable rankings.

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Benefits of SAP HANA streaming analytics

➤ **Part of the SAP HANA Platform**

- Runs as a separate service in the HANA system
- Managed via the HANA Cockpit
- Access to HANA tables in streaming data models

➤ **Scalable**

- Process events in real-time, as fast as they arrive
- Hundreds of thousands to millions of events per second
- Cluster architecture support low-cost multi-node scale out

➤ **Fast – Low Latency**

- Millisecond latency from arrival to response

➤ **Rapid Development**

- SQL-based event process language – familiar and concise
- Both visual and text editors in HANA Studio
- Rich set of testing tools in HANA studio

➤ **Predictive Analytics**

- Built-in predictive models based on machine learning

➤ **Range of Connectivity Options**

- Standard REST and WebSocket interfaces
- Range of standard adapters
- Extensible adapter toolkit
- API's for C++, Java and .NET

➤ **Secure**

- All connectivity/actions require HANA authentication
- Granular access control to the stream/action level

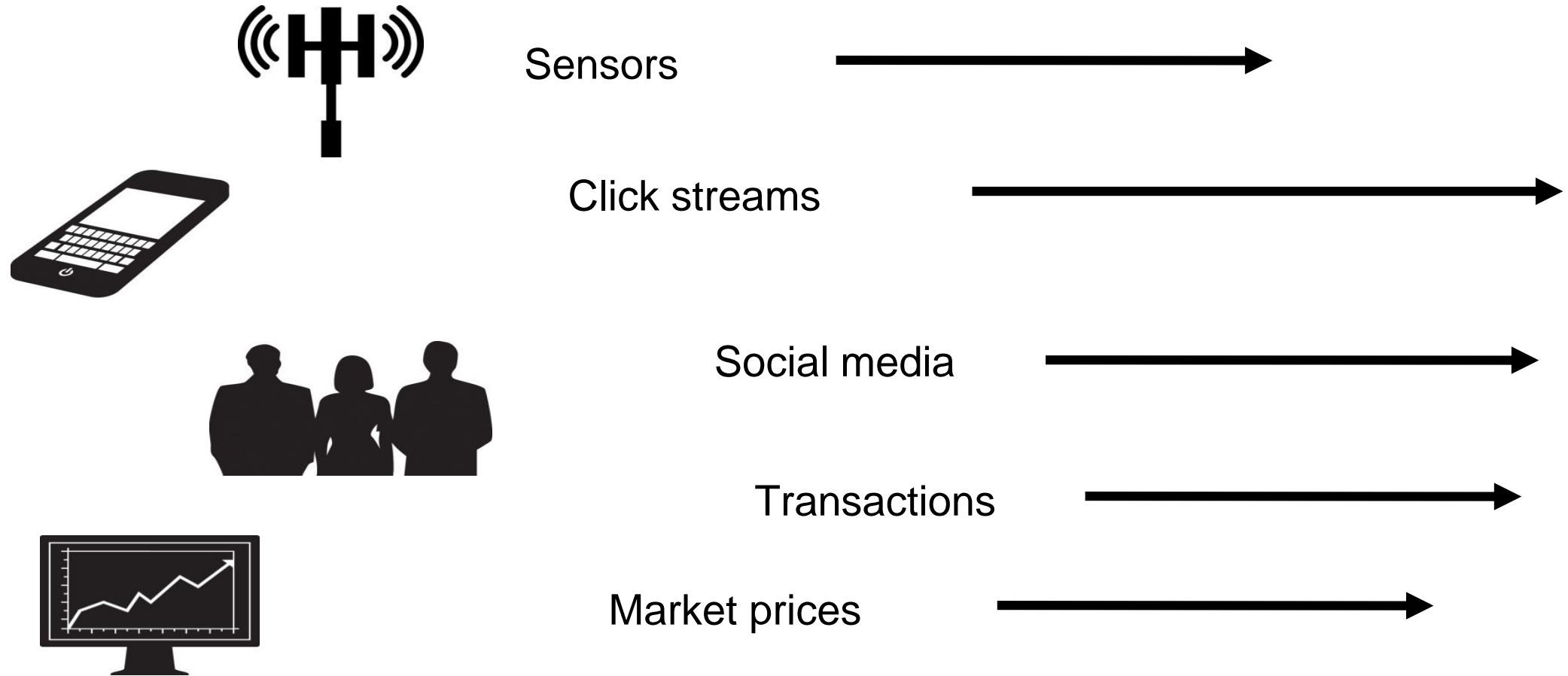
➤ **Fault Tolerant**

- Multi-node clusters with auto-restart
- Cluster managers operate as a peer network
- Event windows can be configured as recoverable



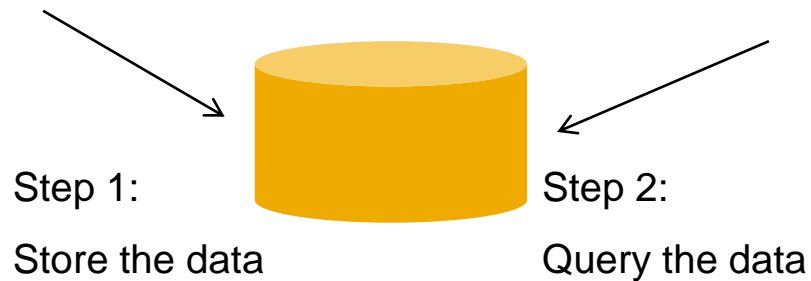
Introduction to Streaming Analytics

Streaming data sources are everywhere

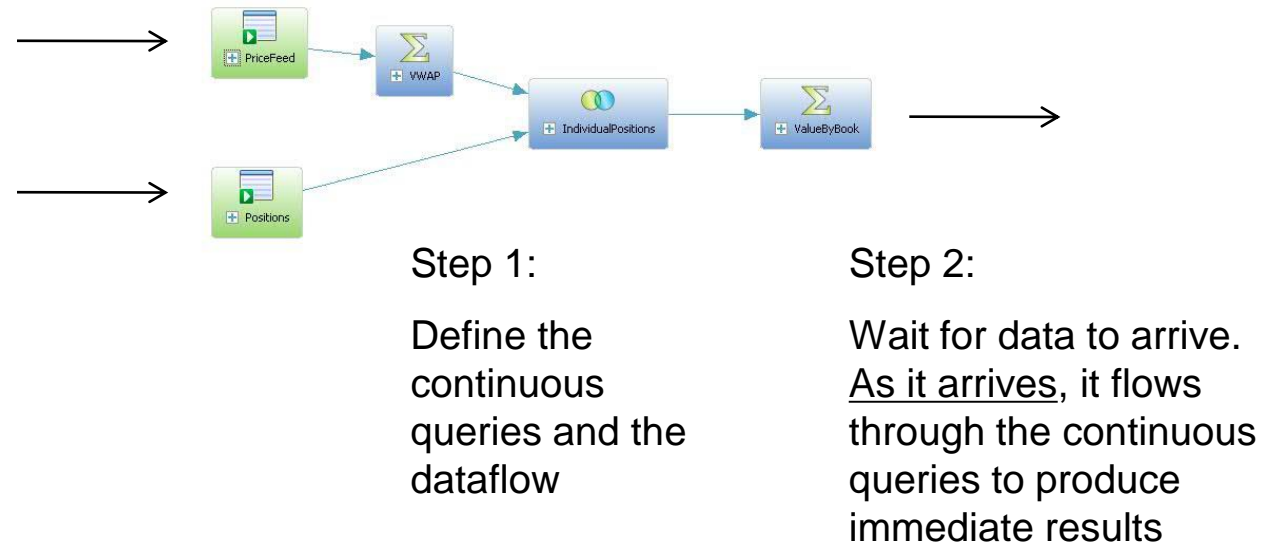


Event stream processing uses continuous queries

Database Queries



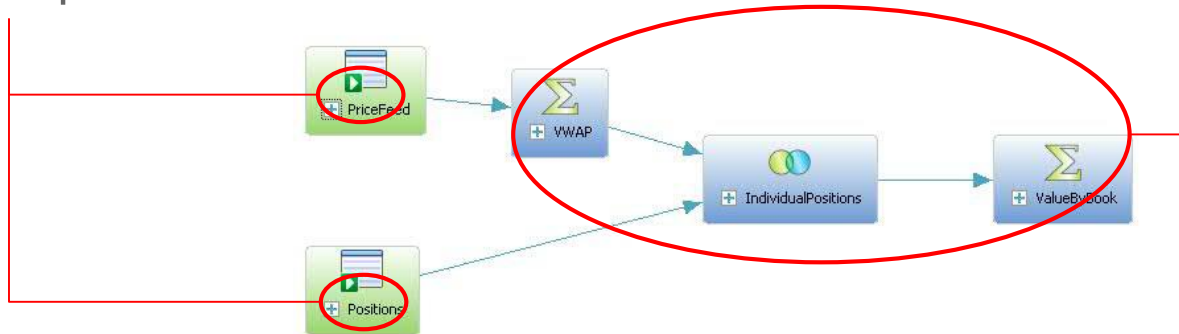
Continuous Queries



Streams and Windows

Input Streams (or windows)

Events arrive on input streams



Derived Streams, Windows

Apply continuous query operators to one or more input streams to produce a new stream

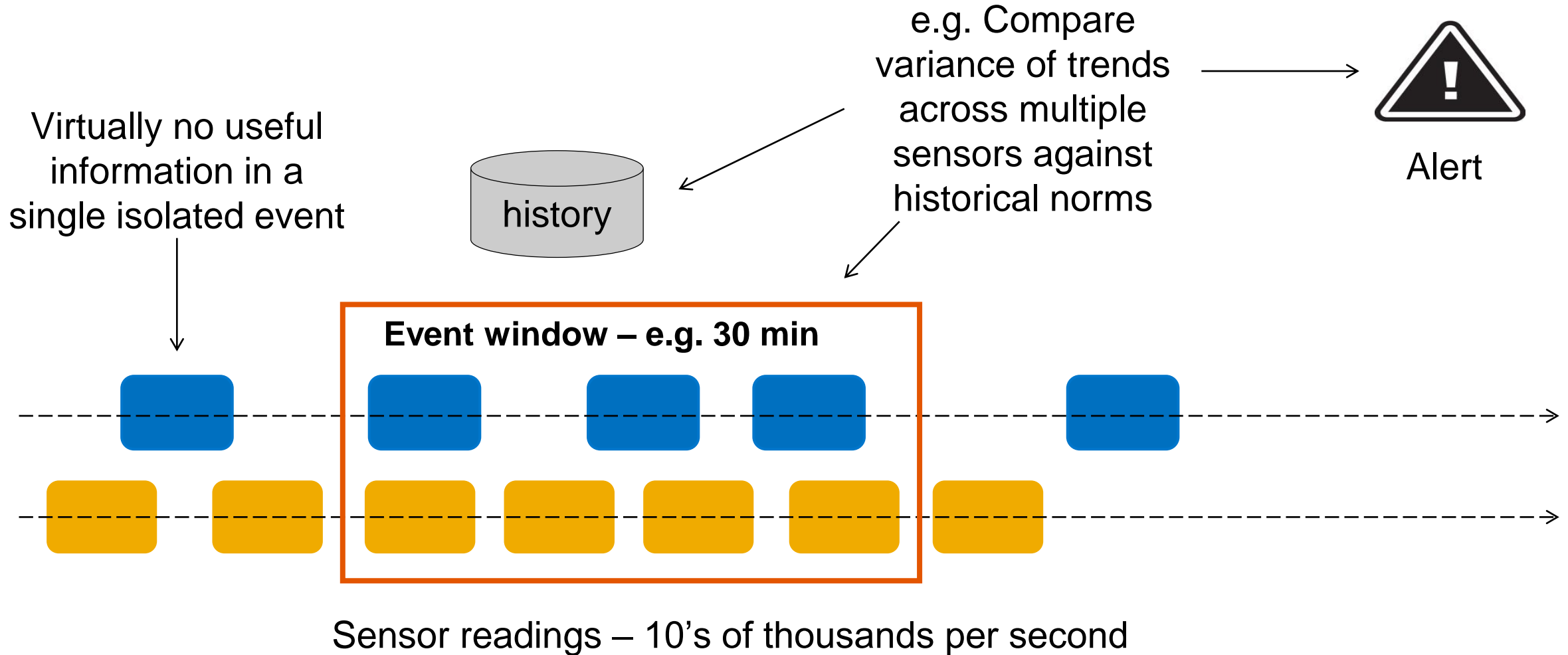
Database Analogy

- Streams are like tables
- Events are rows in the table
- Fields in an event message are columns in the table

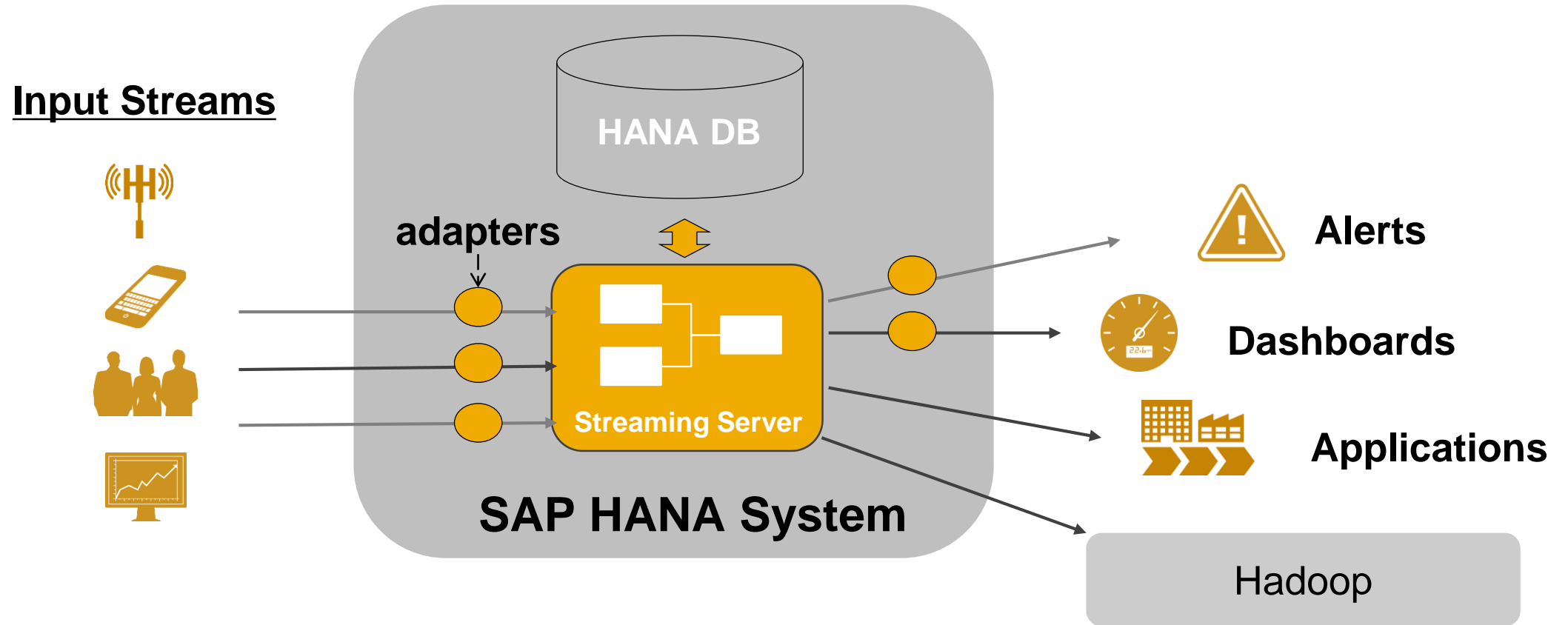
Windows can Have State

- Retention rules define how many or how long events are kept
- Opcodes in events can indicate insert/update/delete and can be automatically applied to the window

Complex Event Processing extracts insight from raw events



Streaming analytics runs as a service of the HANA Platform



Why Streaming Analytics?

Situation Detection

- Watch for trends or patterns
- Spot significant changes
- Monitor correlations
- Compare current values to historical norms
- Apply predictive models to anticipate what's coming

Alerts

Examples:

- Alert a supervisor when a machine needs adjustment before quality is affected
- Alert IT staff as soon as a security threat is detected

Immediate Response

Examples:

- Automatically adjust prices based on market conditions
- Dispatch a technician for urgent preventive maintenance
- Tailor an offer to a user based on current activity
- Shut down a system to prevent damage

Live Dashboards

- Continuously compute and stream summary data to live dashboards

Integrating event streams with SAP HANA

Receive events from streaming sources at high speeds

- Process hundreds of thousands or millions of events per second, in real-time
- REST and WebSocket interfaces
- Kafka, JMS and MQ adapters
- Extensible adapter toolkit plus other standard adapters

Filter, enrich and normalize incoming data

- Rather than capturing all the raw data in HANA, optimize HANA resources by capturing valuable information in an optimized data model

Data reduction

Options include:

- Sample high frequency data to reduce the number of data points
- Only record changes

Data Tiering:

- Store high value data in HANA in-memory tables
- Lower value data in HANA dynamic tiering or in Hadoop
- High speed HANA database loading with support for parallel writing to multiple partitions

Example Use Cases

The Internet of Things: insight from smart devices

Thousands of devices continuously sending bits of information

Insight from combining and correlating

- Combine data across related devices
- Watch for trends or patterns

Active monitoring: alerting and response

- Rather than simply storing the data and analyzing it later
- Identify where there is value in immediate awareness and response
- Let event stream processing generate alerts or initiate immediate action

- ❑ Location monitoring: alert operations staff if equipment is not where it's supposed to be
- ❑ Predictive maintenance: detect imminent failure and take preventative action
- ❑ Smart grid: anticipate overloading and take action before it occurs
- ❑ Personalized offers – based on current activity, location, etc

Use Case – Utilities

Spatial and Graph SAP HANA

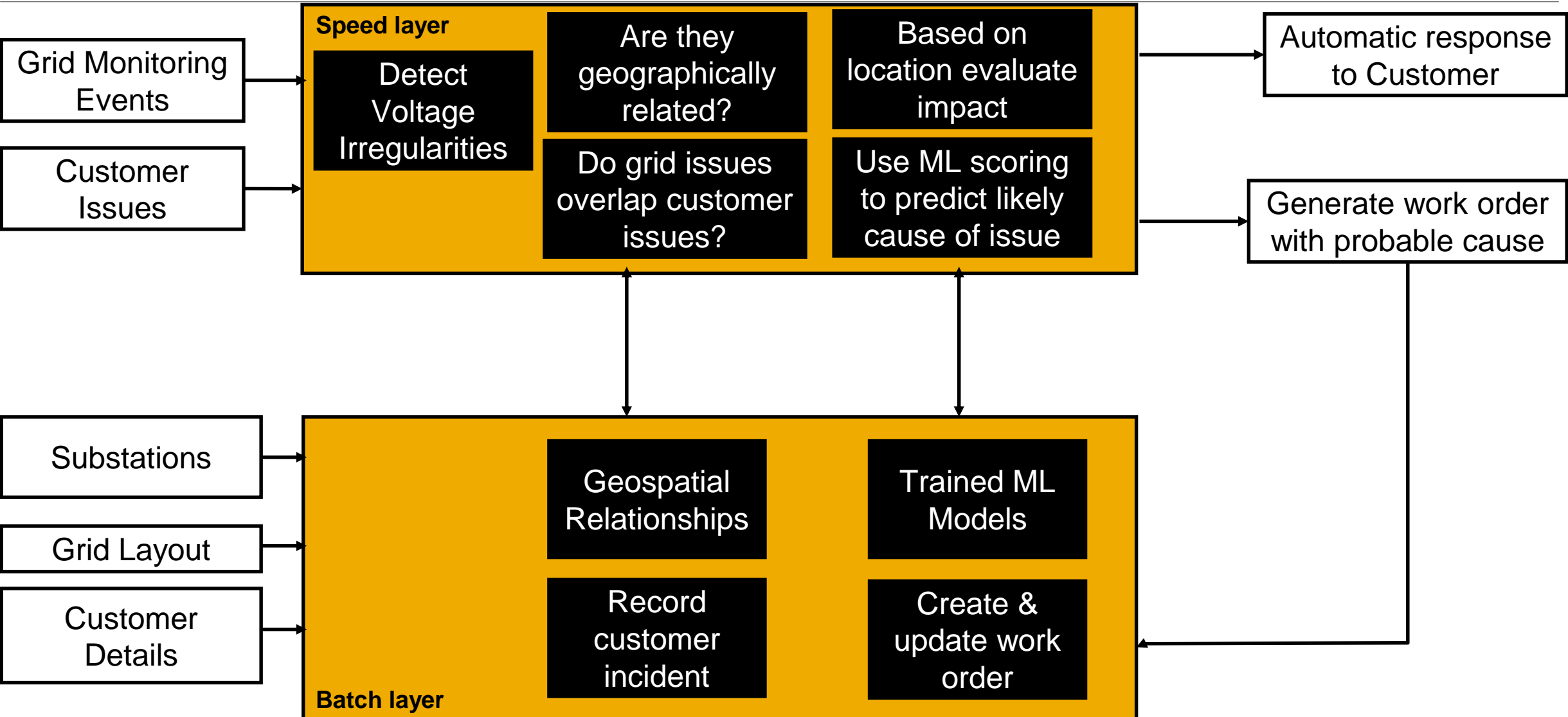
Combine business data with geographical and streaming data.

Example: Proof of Concept with Alliander

Tracing impact of outages in electricity network (47 million records) improves from 3.5 hours to 2.5 seconds.



Use Case – Utilities



Improving Energy Demand Response with SAP HANA® Streaming Analytics



Company Name

Swiss Federal Railways (SBB)
Bern, Switzerland
www.sbb.ch

Industry

Travel and transportation

Products and Services

Passenger and cargo
transportation

Employees

33,000

Revenue

€7.9 billion (2016)

SAP Solutions

SAP HANA
SAP HANA streaming
analytics

Implementation Partner

SAP Innovative Business
Solutions

As part of its long-term load management program, SBB worked with SAP Innovative Business Solutions to create a smart, real-time power demand management platform based on SAP HANA® streaming analytics. The solution will automatically decrease peak loads and is expected to reduce SBB's energy costs. After a successful proof of concept, SBB now has the foundation for its ongoing energy management transformation.

Before: Challenges and Opportunities

- Manage constantly fluctuating energy demands more efficiently
- Respond to frequent, sudden peak loads during rush hours and in winter when heating is at maximum
- Implement a system that monitors power demand in real time and automatically reduces load by proactively switching off energy-consuming appliances, such as heaters

Why SAP

- Implement standard software with SAP HANA streaming analytics to form the smart core of a complex signal processing solution and provide a proven foundation for future innovation projects
- Close collaboration between SAP and SBB, working as one unified team in Switzerland from the proof of concept to development of SAP-specific system components
- Using agile methodology, the SAP Innovative Business Solutions team delivered a proof of concept in just six weeks

After: Value-Driven Results

- Postponed investments in new energy infrastructure by leveraging existing assets
- Savings in peak energy costs expected
- Increase the reliability of energy supply
- New opportunities to control other energy-consuming appliances in the future, such as train traction (engines)

“By realizing our power demand management platform, we’re building the foundation for future business cases.”

Markus Halder, Head of Power Demand Management Program, SBB

Dynamic

power demand management

Real-time

responses to power peaks

6 weeks

rapid prototyping to deliver
proof of concept

[Learn more >](#)

Providing a Next-Generation Air Service with SAP® Leonardo Internet of Things

Kaeser Kompressoren SE
Coburg, Germany
www.kaeser.com

Industry
Industrial machinery
and components

Products and Services
Compressed air systems
and compressed air
consulting services

Employees
5,500

SAP® Solutions and Services
SAP® Leonardo Internet of Things (IoT) capabilities, SAP Asset Intelligence Network, SAP Predictive Maintenance and Service solution, and SAP Digital Business Services

To optimize its Sigma Smart Air Service, Kaeser worked with SAP Digital Business Services to deploy SAP Leonardo IoT capabilities as its innovation foundation together with SAP Asset Intelligence Network and SAP Predictive Maintenance and Service. Kaeser's new solution connects its compressors smartly in the cloud, allowing it to offer a next-generation service at a lower price.

Before: Challenges and Opportunities

- Service team unable to access calibration data and other equipment-specific information, which was stored in on-premise systems
- No solution to meet the needs of dealers and companies' service providers
- Need for track-and-trace capabilities with selected suppliers to scale up potential

Why SAP

- Strategic partnership and co-innovation with SAP
- SAP Asset Intelligence Network based on SAP S/4HANA® Cloud for use in maintenance of equipment information and greater transparency over usage
- Standard integration between SAP S/4HANA, SAP Predictive Maintenance and Service, the SAP Manufacturing Execution application, and third-party solutions
- Ability to establish a "digital twin" to build entirely new data-driven business models

After: Value-Driven Results

- Increased service efficiency with one single source of product, component, spare-part, and service information
- Higher customer and dealer satisfaction with an up-to-date digital replica and improved supplier collaboration
- Greater transparency across the company's installed base, enabling it to offer additional digital services and new business models
- Enhanced flexibility of a cloud-based solution

"SAP Leonardo technologies provide the framework for different applications that can be easily combined to orchestrate your own business model."

Falko Lameter, CIO, Kaeser Kompressoren SE

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New

Business models based on
real-time data

Higher

Customer lifetime value and
service efficiency

>1 million

Measurements per day to avoid
unplanned downtime



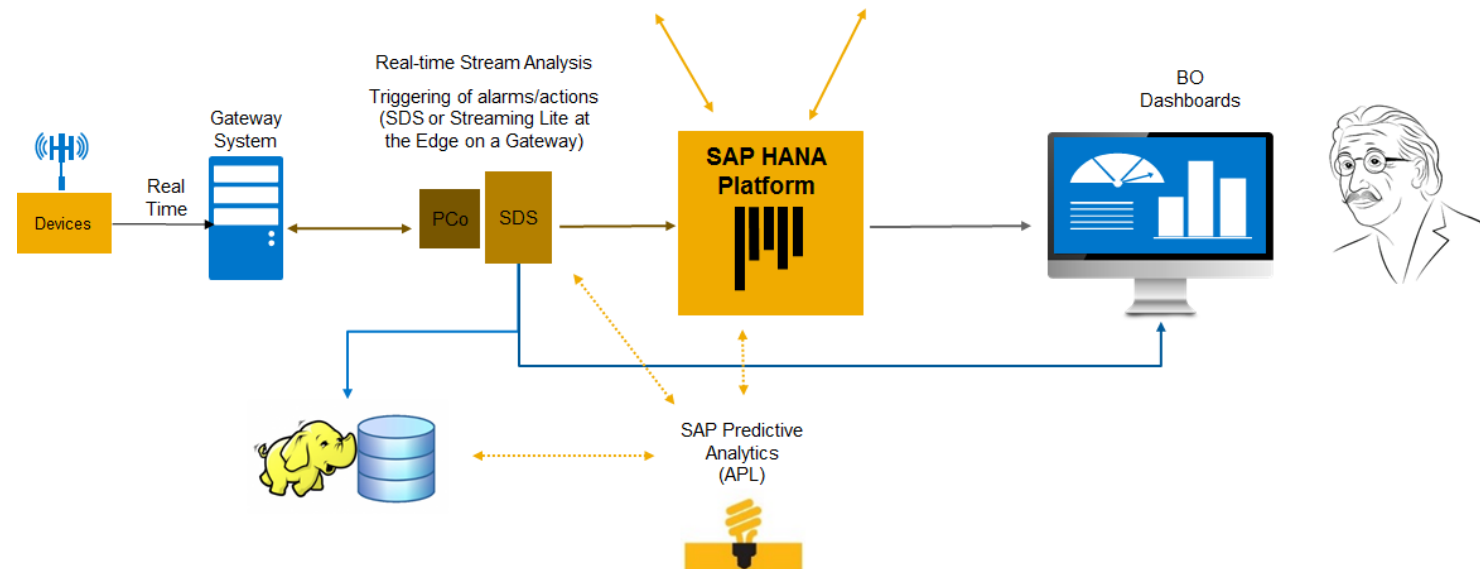
See how Kaeser boosted its air-service
business with SAP software.

Continuous Manufacturing - Paper Breakage Use Case



Manufacturing Execution*
Realtime Quality Prediction
in MES for Operator

SAP ERP*
(via QM, PP, MM)
Quality Tests



Preventing paper breakage, reducing waste production and time-to-quality are key

Fusion of sensor measurements and quality parameters to derive predictive models for real-time implementation to reduce paper breakage

Leads to:

- ❑ Decrease production losses
- ❑ Increase plant utilization
- ❑ Reduce time-to-quality, in particular for rarely and never-before produced materials
- ❑ Monitor, guarantee and possibly improve continuous quality standards

Industrial Worker Safety – Gas Leak & Fall Detected

Scenario 1



Wearable Sensors

Joe is an electrician working in hazardous conditions. He is equipped with a number of wearable IoT sensors that can detect dangerous gas levels, his heart rate and his posture.

Dangerous Gas and a Fall!

The sensors monitor in real-time for unsafe conditions. As the sensor detects dangerous levels of gas Joe is alerted and attempts to make his way to safety, on his way he falls and is left lying on the ground.

Alert Manager

Data from Joe's sensors stream real-time to his manager's dashboard. The safety manager is first alerted of the gas and then a second alert to indicate the fall. An emergency response team is sent to aid Joe.

Report Incident

With Joe now safe, his manager can complete the necessary Incident Reporting, this task is sped up due to an automatically created incident report which has prefilled much of the incident information based on the alert.

Analyze Data

Once the incident is submitted, analysts at head office can use relevant IoT sensor data automatically included with the report to look for trends or patterns and to try to make the workplace safer.

SAP Enterprise Threat Detection

The magnitude of the problem:

- The most important logs in an SAP system generate altogether between 100k and 1M records/hour
- 300 systems generate up to 300M records/hour, which is about 90GB/hour

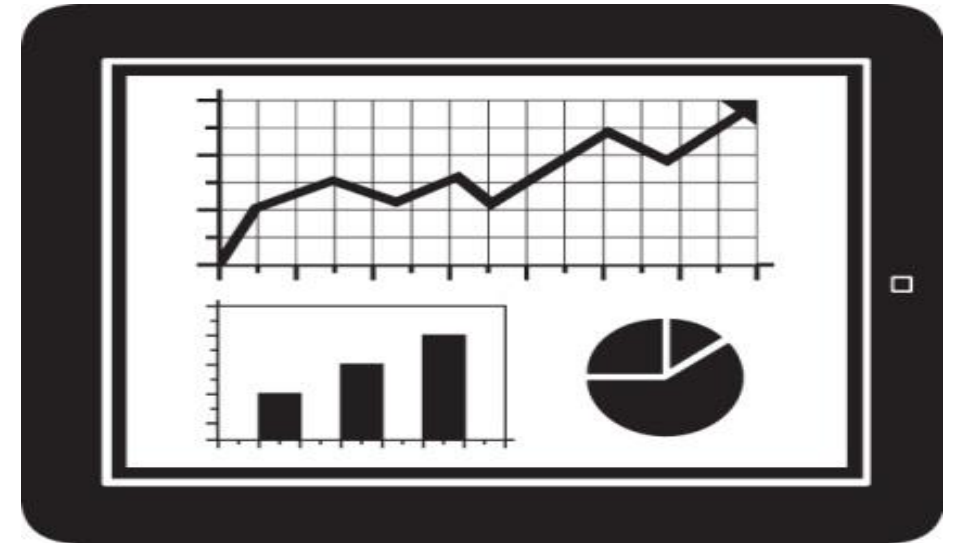
Types of attack patterns:

- Related to human behavior
- Of technical origin

Browse and explore events

- Overview by system, timeframe, context, ...
- Filter and search
- Create alerts

View and work on alerts



Real-time click stream analysis

Monitor user behavior in aggregate

- Respond to trends in real-time
- Jump on surges before they subside
- Give more prominence to topics attracting viewers now

Customize offers based on individual patterns of behavior

- Don't limit customization to historical behavior, but include current behavior

Prevent fraud

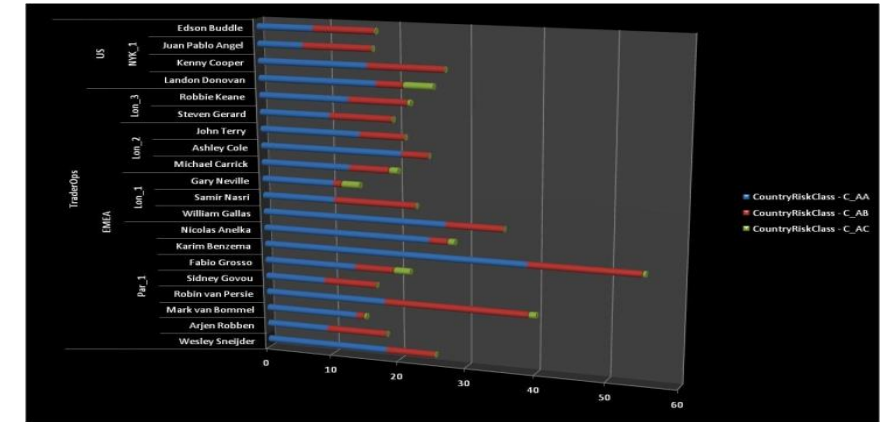
- Watch for patterns that indicate likelihood of fraud; act before the fraud takes place



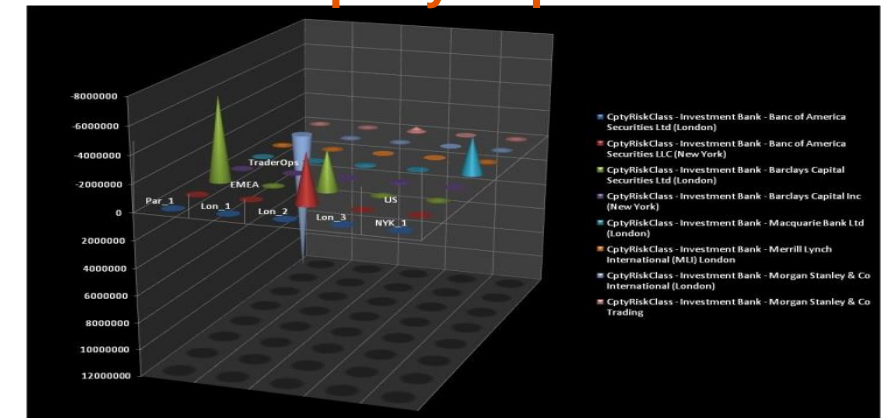
Real-Time Financial Risk Consolidation and Monitoring

- Real-time consolidation across multiple trading platforms, multiple asset classes
- Real-time valuation using live market prices
- Custom pricing algorithms for non-liquid securities
- Incoming trades immediately update all sensitivity calculations
- Real-time P&L calculations
- Continuous limit monitoring and alerting; set limits at any aggregation levels

Trader Limits



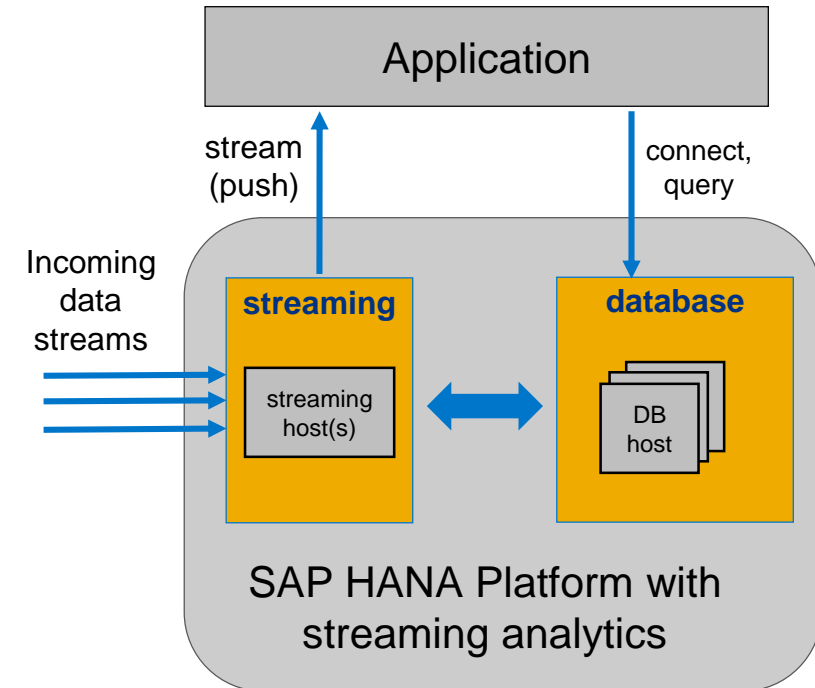
Counterparty Exposure



Deployment

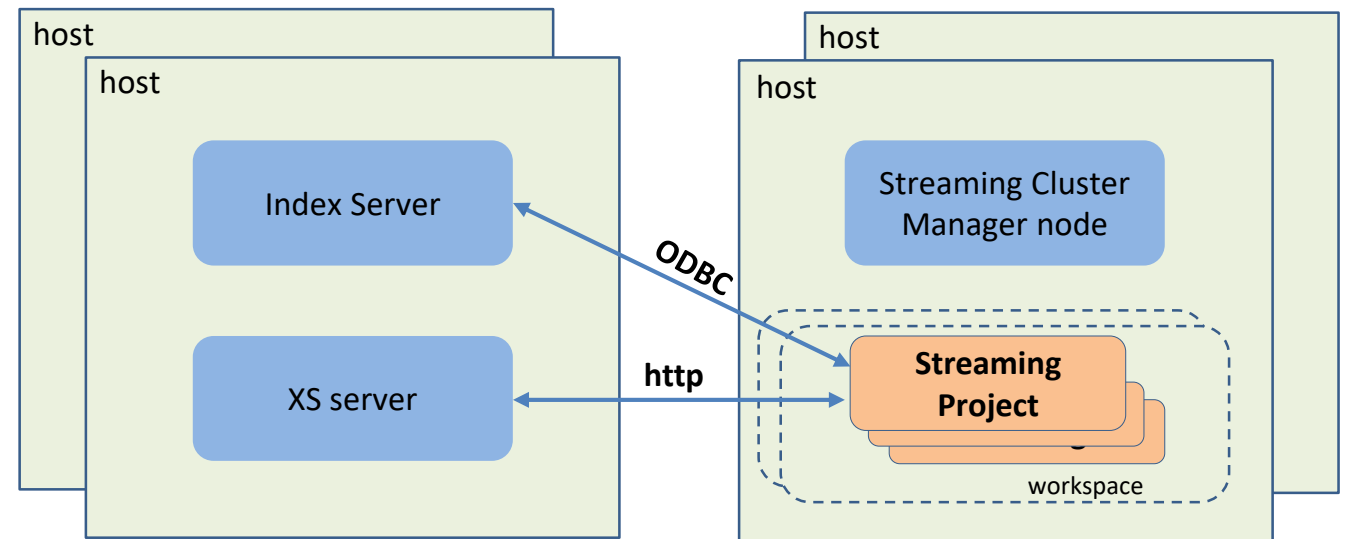
What does this look like to a HANA application developer?

- For production systems, it's normally recommended to run streaming on dedicated machines – but can be low-cost commodity Linux servers (doesn't require HANA certified hardware)
- Design time tools are available as a plugin to SAP HANA Studio or SAP Web IDE
- Installed via HANA Installer
- Streaming server(s) runs on dedicated host(s)
- Administration via SAP HANA Studio and Cockpit
- Streaming projects are managed in the HANA repository and can be included in, and deployed as DU's
- Optional – licensed separately from base



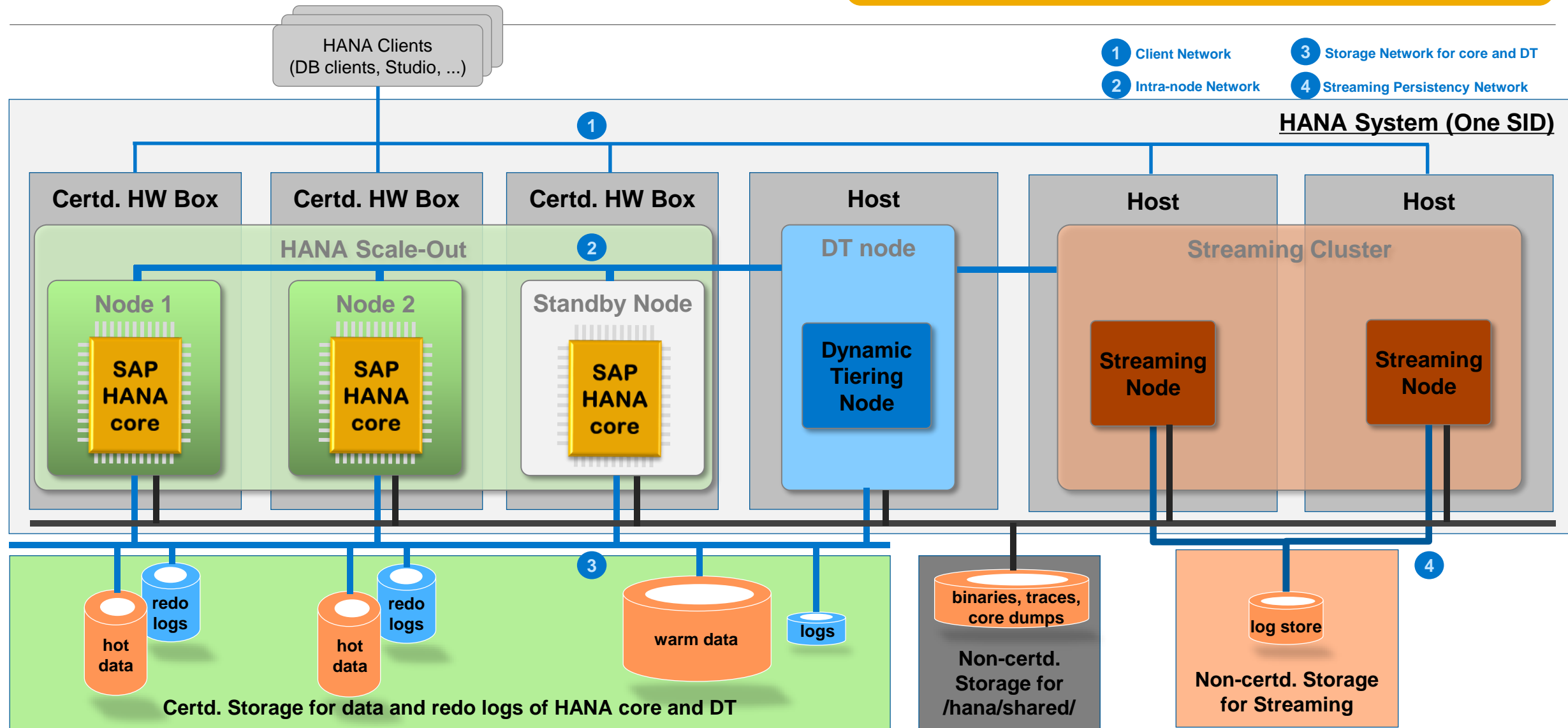
SAP HANA system with a one or more streaming nodes

- Streaming capacity scales independently of SAP HANA database
- Add streaming nodes for additional stream processing capacity
- Streaming projects connect to SAP HANA database via SAP HANA ODBC driver
- Streaming projects can send events to XS application using http output adapter



Hardware Layout View

Streaming hosts can be, but do not have to be, HANA-certified servers



Hardware considerations

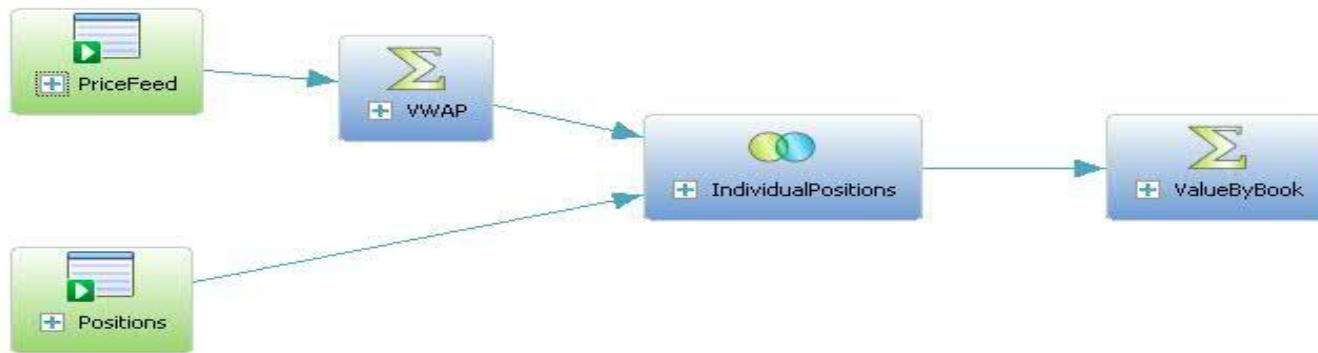
- Although streaming does not require HANA-certified configuration, hardware should be from an SAP hardware partner: <http://scn.sap.com/docs/DOC-8760>
- See the streaming analytics sizing guide for indicative capacity for each of the T-shirt sizes. Some systems can go much larger (e.g. 200 cores)
- System configuration must consider network bandwidth and HANA DB workload for stream capture
- [SAP HANA Smart Data Streaming Sizing and Configuration Guidelines](#)

T-Shirt Sizes

	Cores	RAM (GB)
S	4	8
M	8	16
L	16	32
XL	32	64

Streaming Scalability

- Streaming projects are multi-threaded and will scale across all available cores
- Streaming hardware scales independently of HANA core; can run one or more streaming nodes in a single HANA system
- Large projects can be broken into smaller inter-connected projects running on different nodes
- Partitioning feature eliminates bottlenecks within a project by providing multiple parallel processing paths



SAP HANA streaming analytics provides extreme scalability.

Throughput capacity can always be increased by adding hardware.

Installation of HANA streaming analytics

1. Download from Service Marketplace

- Separate download from SAP HANA core (since it's optional)

2. Install via SAP HANA installer

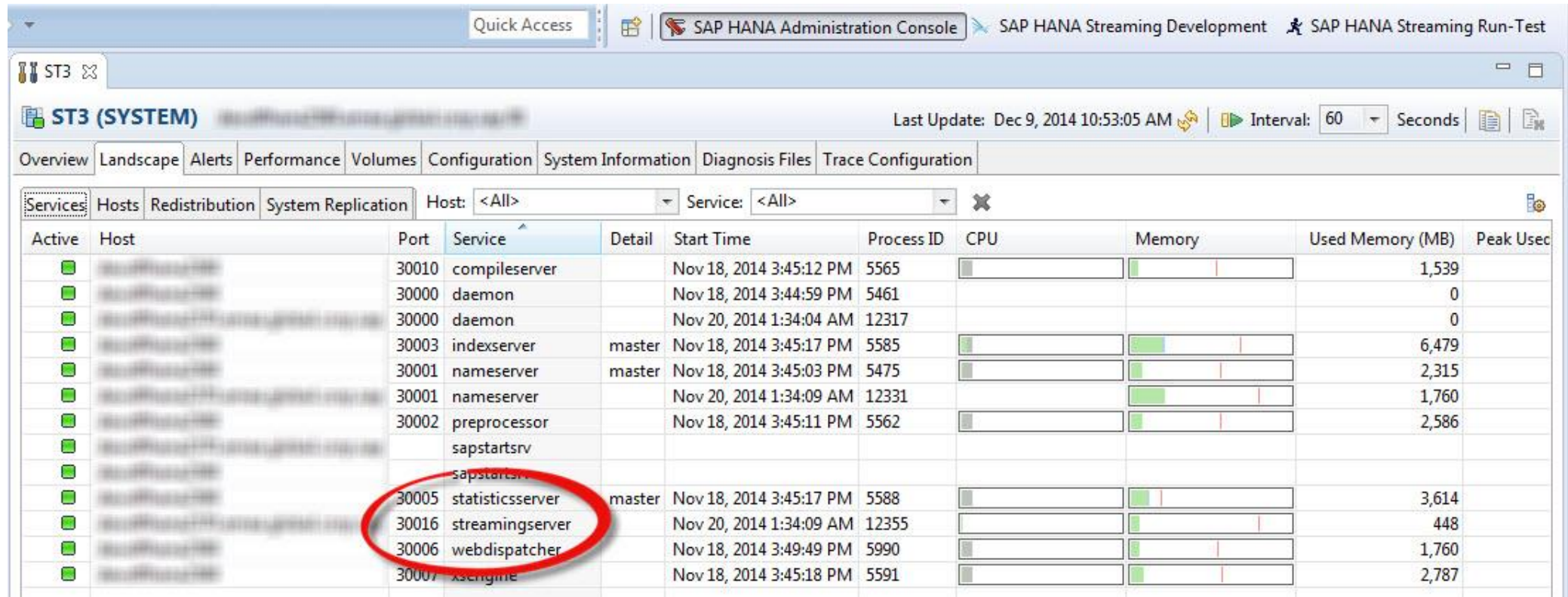
- Add to an existing SAP HANA system
- Install as part of a new SAP HANA system install

3. Additional download packages:

- Streaming studio plugin (for HANA Studio)
- Streaming analytics client package – adapters, ODBC driver, SDK's

Streaming server(s) in the SAP HANA Administration Console

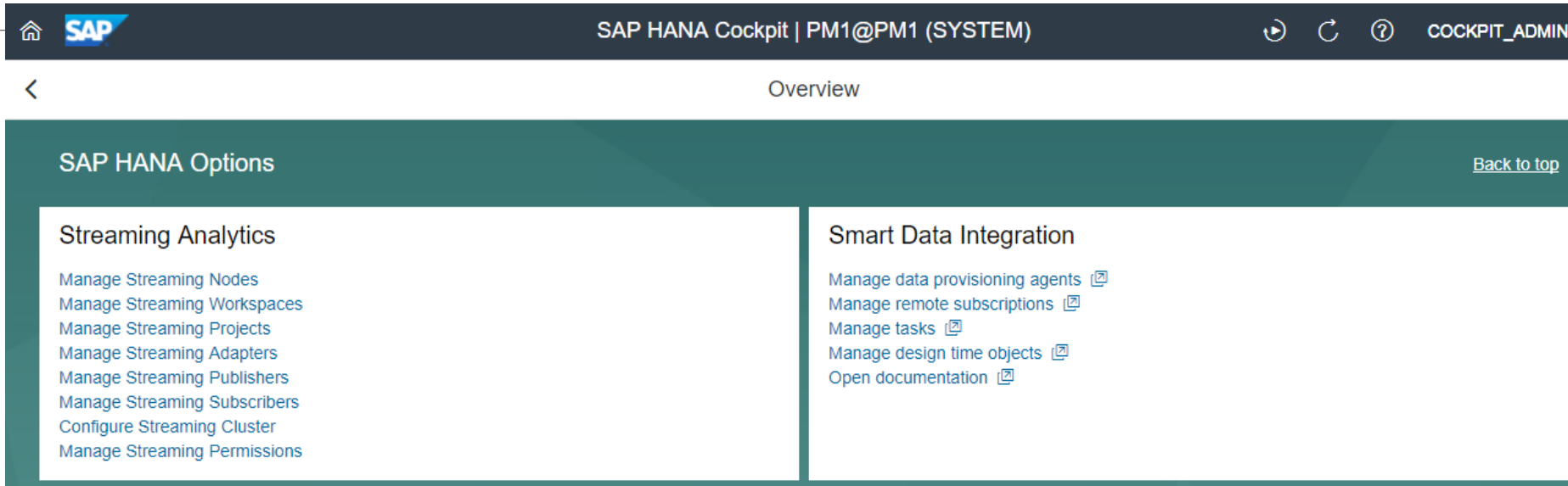
- Streaming nodes will be listed in the landscape view of the SAP HANA Administration Console in the HANA Studio
- Will show status and provide ability to stop/start nodes. Use HANA Cockpit for project-level control



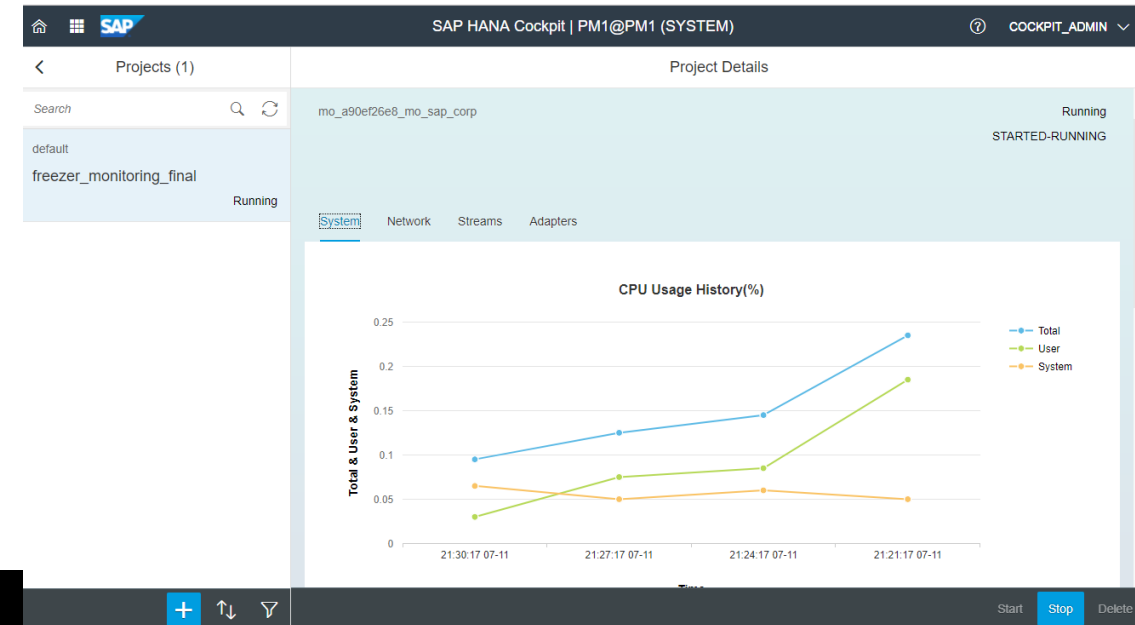
The screenshot shows the SAP HANA Administration Console interface. The 'Services' tab is selected, displaying a list of system services. The 'streamingserver' entry is highlighted with a red circle. The table includes columns for Active status, Host, Port, Service, Detail, Start Time, Process ID, CPU usage, Memory usage, Used Memory (MB), and Peak Used Memory.

Active	Host	Port	Service	Detail	Start Time	Process ID	CPU	Memory	Used Memory (MB)	Peak Used
	...	30010	compileserver		Nov 18, 2014 3:45:12 PM	5565			1,539	
	...	30000	daemon		Nov 18, 2014 3:44:59 PM	5461			0	
	...	30000	daemon		Nov 20, 2014 1:34:04 AM	12317			0	
	...	30003	indexserver	master	Nov 18, 2014 3:45:17 PM	5585			6,479	
	...	30001	nameserver	master	Nov 18, 2014 3:45:03 PM	5475			2,315	
	...	30001	nameserver		Nov 20, 2014 1:34:09 AM	12331			1,760	
	...	30002	preprocessor		Nov 18, 2014 3:45:11 PM	5562			2,586	
	...		sapstartsrv							
	...		sapstartsrv							
	...	30005	statisticsserver	master	Nov 18, 2014 3:45:17 PM	5588			3,614	
	...	30016	streamingserver		Nov 20, 2014 1:34:09 AM	12355			448	
	...	30006	webdispatcher		Nov 18, 2014 3:49:49 PM	5990			1,760	
	...	30007	xengine		Nov 18, 2014 3:45:18 PM	5591			2,787	

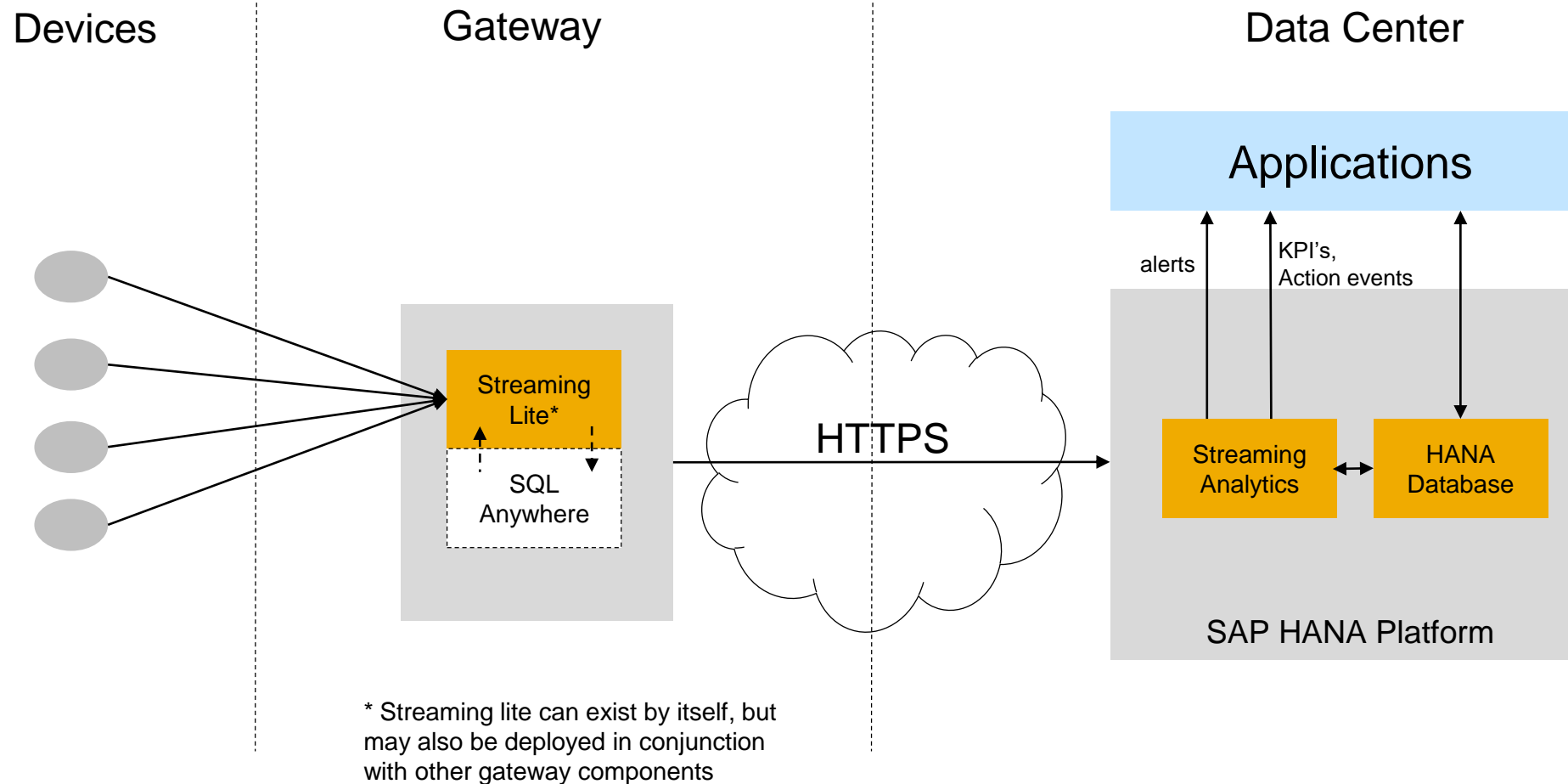
HANA Cockpit: Centralized Monitoring and Administration



- Options for managing nodes, workspaces, projects, adapters, etc.
- Drilling down provides additional detail. For example, clicking on the "Manage Streaming Projects" option will open up the page "Project Details".



Streaming Lite: HANA HSA Remote Deployment Option



- Deployment option included with SAP HANA streaming analytics
- CCL projects can run at the edge
- Small footprint package
- Supported on ARM and Intel processors
- Certified on Red Hat and Raspbian

Streaming Lite

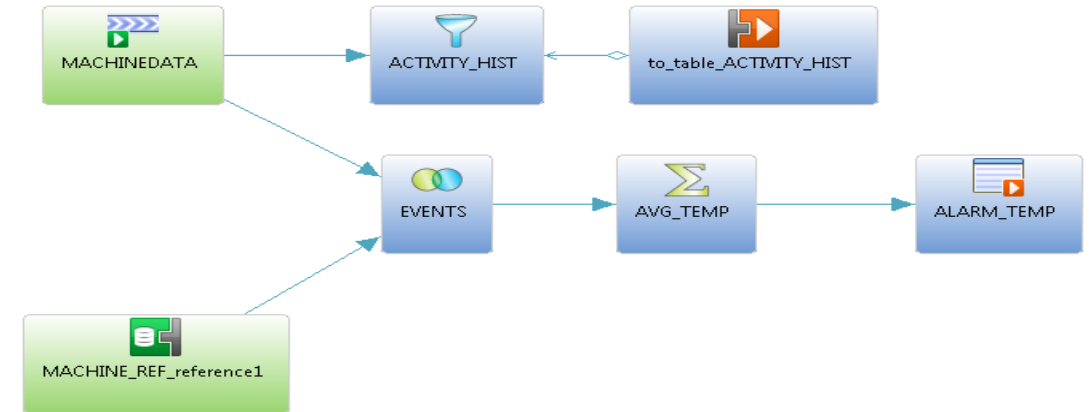
- **Light-weight HSA server** process designed for gateway deployment in IoT scenarios
 - Smaller install image - reduced disk and memory footprint
- Compiled **CCL project runs as a stand-alone Linux process** (no HANA system, no SDS cluster)
- Supported on Linux: **32 bit ARM and 64 bit Intel x86** (or compatible) processors
 - Certified on **Raspberry Pi** with Raspbian (for 32 bit ARM)
- Streams **output via WebSocket to SDS**
 - New internal output adapter to stream output from Streaming Lite (at the gateway) to HANA smart data streaming in the cloud, via WebSocket

- **Filter close to source**
 - Reduce bandwidth and need for excessive central capacity
 - Not limited to simple filtering: can apply complex, dynamic filter criteria
- **Aggregate**
 - Examples include: reduce sampling rate; reporting trending rather than raw values
- **Local alerting/response**
 - Generate local alerts or response without relying on round-trip to center (or even connectivity to center)

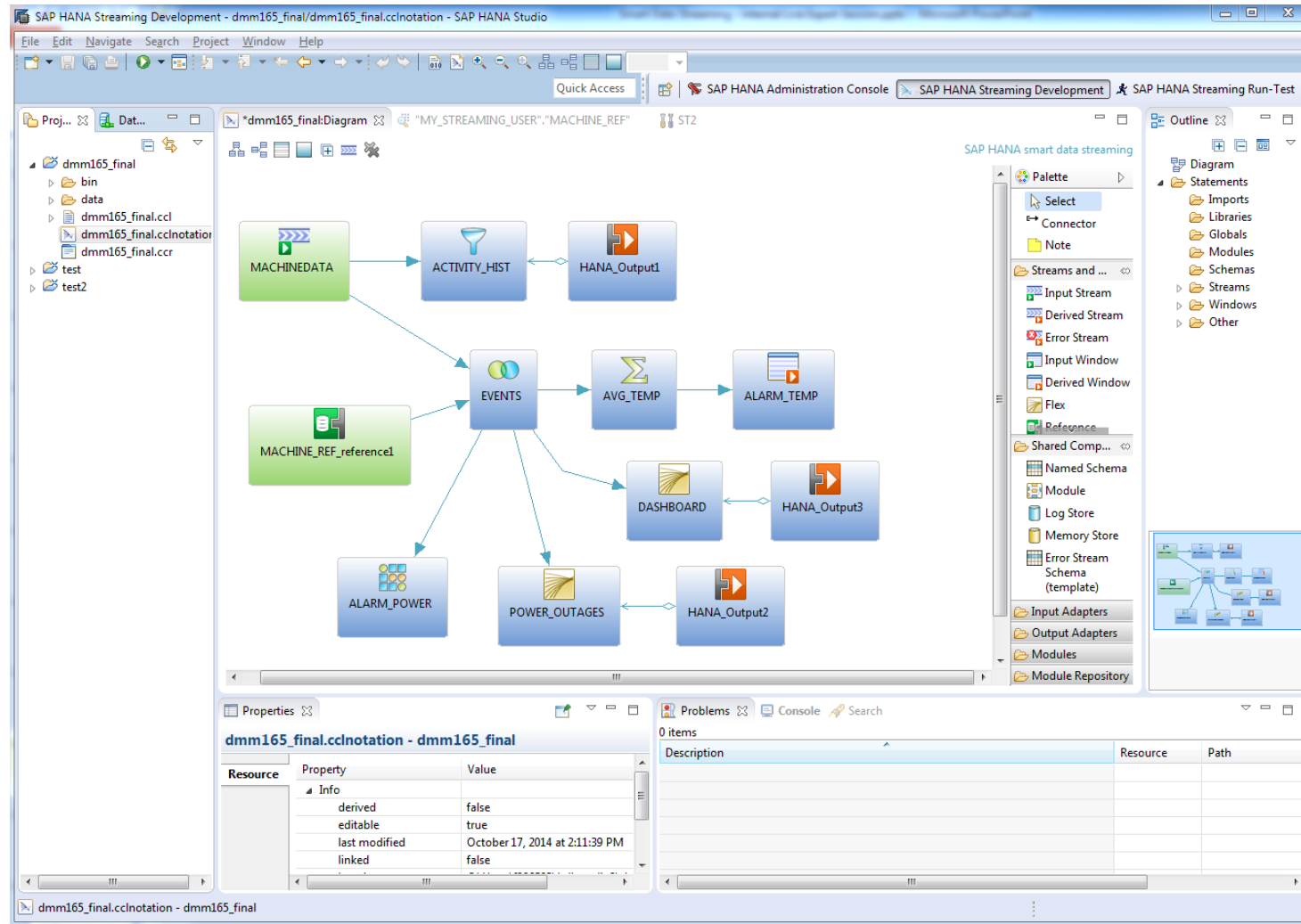
Design Time

Design Time

- Streaming “projects” define the input streams, continuous queries, and outputs
- Projects are defined in CCL – the stream processing language used
 - Derived from SQL for familiarity and ease of use
 - Models can be defined in just a few lines of CCL
 - Maximizes user productivity
- Streaming plugin for Eclipse provides both a CCL editor and visual editor, along with testing tools



Design time tools for Eclipse / SAP HANA Studio



Streaming plug-in for Eclipse includes a visual editor for defining continuous queries and directing stream flow, plus run/test tools

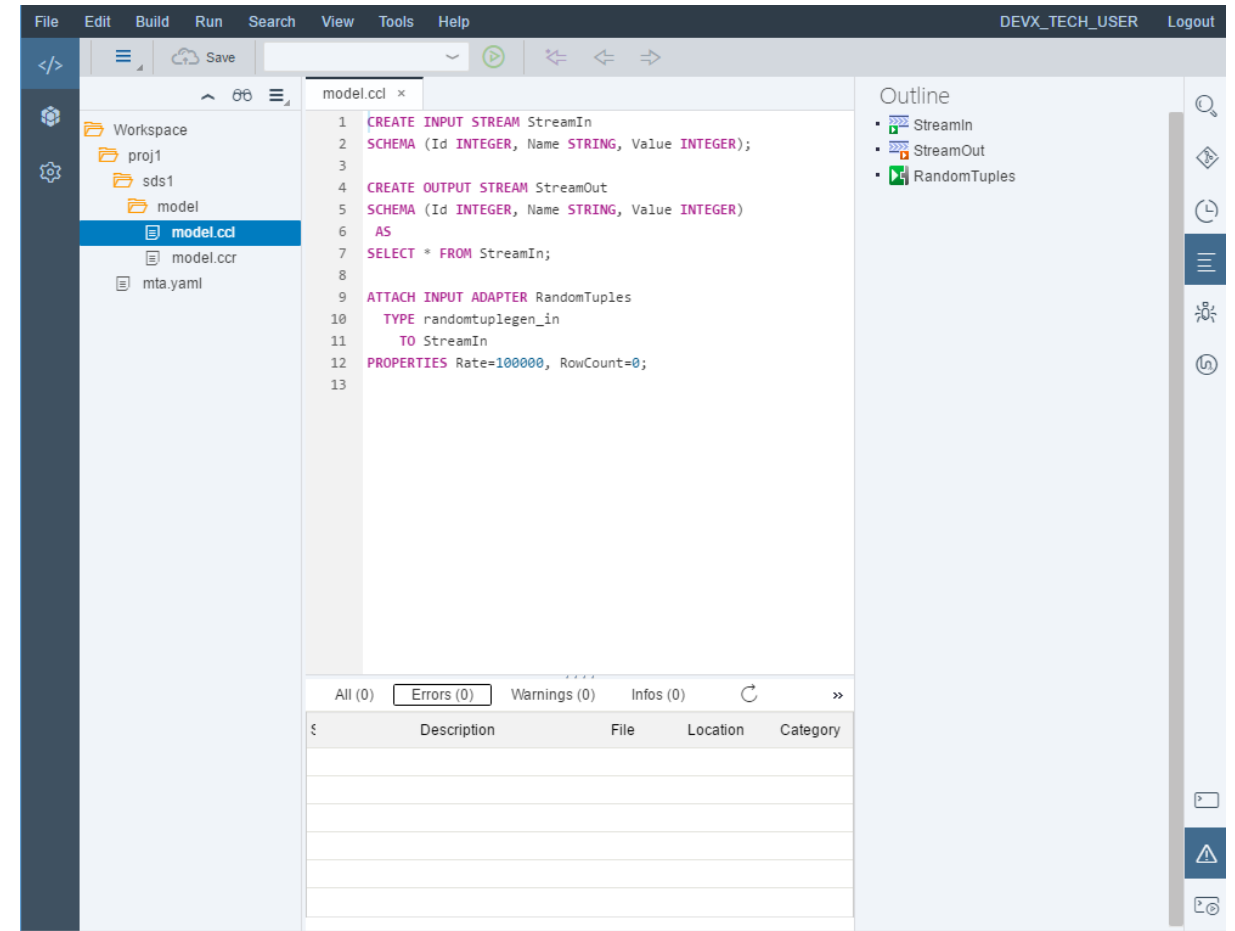
- Event processing language: CCL (like SQL for streams)
- CCL Script (like event driven stored procedures for streams)

HANA Streaming Analytics Design Time Tools in SAP Web IDE for SAP HANA

Web based tooling is now viable as an SDS design time environment independent of SAP HANA Studio

- Add streaming modules to multi-target applications
- **Enhancements to CCL editor:** Parsing and Syntax highlighting, editor auto-completion, semantic error checking, improved compilation error handling, ability to add CCL snippets for ease of use.
- **Visual project viewer:** view the diagram of a CCL project (read only – no visual editing)
- **Run-Test Tools:** project start/stop, stream viewer, record/playback, manual input, file upload, manage data services

Note: Not yet a full functional replacement for SAP HANA Studio. There are still advanced features available in Studio that are not yet available in the browser-based tools.



CCL: Continuous Computation Language

SQL-based Event Processing Language

Leverage familiarity and simplicity of SQL

Instead of “snapshot” queries, *continuous queries*

Filter (WHERE), Aggregate (GROUP BY), Join, Compute

Extensions for event streams

Windows, Patterns

Example	CCL Query
Calculation of 10 minute moving average	<pre>CREATE WINDOW MovAvg10 PRIMARY KEY DEDUCED AS SELECT instream.ID AS ID , avg (instream.VALUE) AS Avg FROM instream KEEP 10 MINUTES GROUP BY instream.ID ;</pre>

Predictive Analytics for Streams

Machine Learning Algorithms

Native Algorithms

- Adaptive Hoeffding Tree
- Denstream Clustering

Imported Scoring Algorithms

- Leverage HANA Predictive Analytics Library (“PAL”)
- CART
- C4.5
- CHAID

Tooling Integration

- SAP Business Objects Predictive Analytics
 - Automated Analyst Persona
 - Scoring algorithms generated in CCL

Machine Learning Algorithms: predictive analytics for streams

Adaptive Hoeffding Tree

- Train against live data streams, continuously updating the model, discovering predictive relationships
- Score incoming data using the trained model

Denstream (Clustering)

- Incremental clustering algorithm continuously adapts to incoming data
- Assign incoming events to clusters
- Identify outliers

Imported Decision Trees

- Train models using standard PAL decision tree algorithms against historical data in SAP HANA
- Import models into HSA project and use them for live scoring of incoming events

Identify outliers

Decide when action is needed – and what action to take

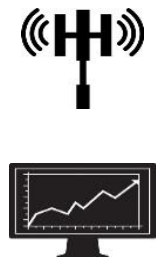
Streaming projects connecting to HANA tables and views

- **High speed event stream capture into HANA tables**
- **Update HANA tables based on analysis of incoming event streams**
 - Streaming projects can apply inserts, updates, and deletes to HANA tables – not limited to event logging
 - This allows HANA tables to “mirror” event windows in streaming projects
- **Join event streams to HANA tables/views**
 - Reference HANA tables/views directly in CCL projects
- **Pre-load reference data from HANA DB into streaming projects**
 - With ability to set refresh interval
- **Run event-driven analytics on HANA DB**

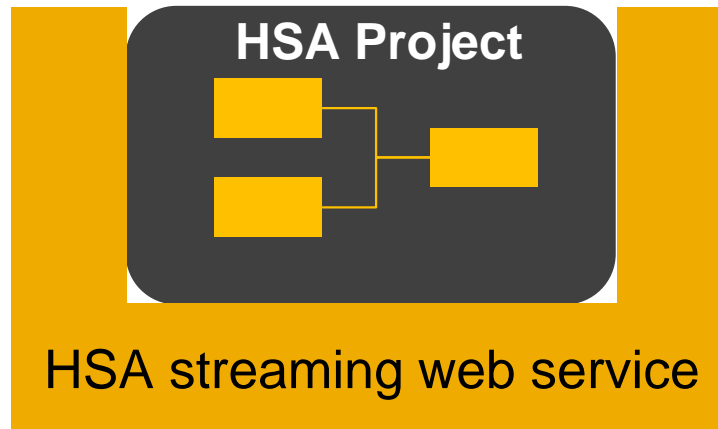
Connectivity

Connecting via HSA Web Services (REST, WebSockets)

Data sources



http/websocket



http/websocket



Alerts

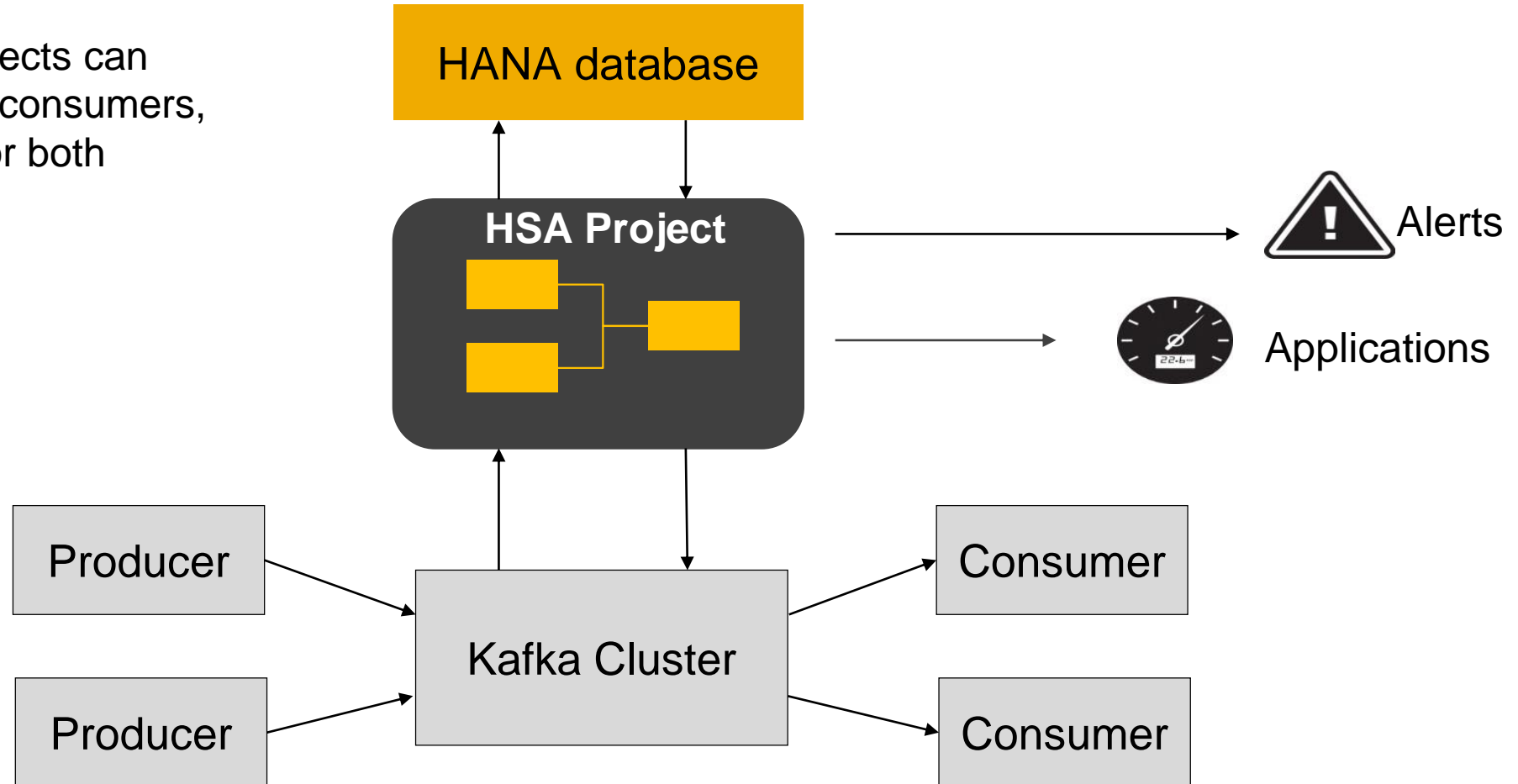


Applications

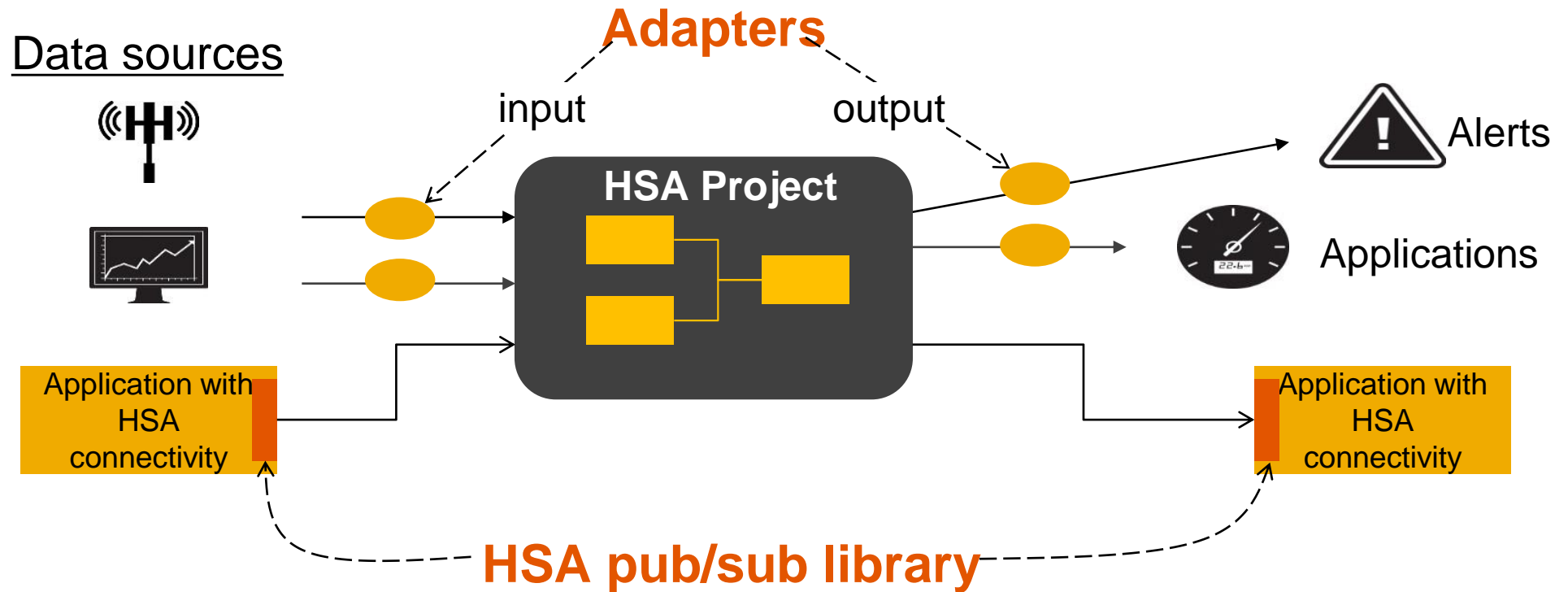
- The HSA server provides connectivity to HSA projects via a “streaming web service”
- Publishers have a choice of http/REST or WebSockets
- Subscribers can browse meta-data via REST API and subscribe to output streams via WebSockets

Kafka Support

Streaming projects can connect as Kafka consumers, producers, or both



Overview of other HSA integration options



Input adapters receive/fetch messages using a protocol supported by the source, parse the message, and publish it to HSA as an event. Output adapters do the same – in reverse.

The HSA SDK (C++, Java, .NET) provides a library that can be embedded in adapters or applications to connect to SDS and publish/subscribe

SAP HANA streaming analytics provides a range of connectivity options

Standard:

- http: REST, WebSockets
- Messaging: Kafka, JMS, MQ, TIBCO
- SOAP
- Databases
- Files
- OSIssoft
- TCP Sockets
- SAP RFC
- SAP Replication Server (in)
- Logfile (in)
- Microsoft Excel (out)
- Email (out)

Parsing/Formatting

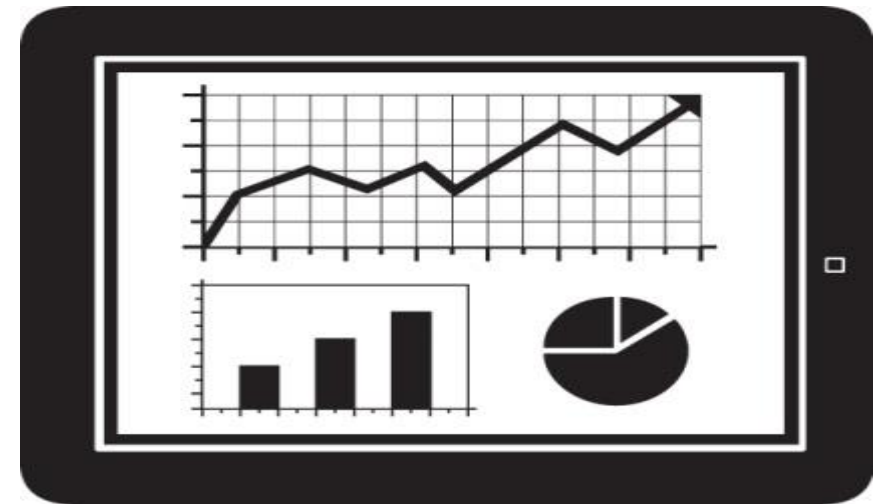
- JSON, Avro
- XML events
- XML docs
- CSV
- FIX
- JMS Object Arrays

Custom/Extensible:

- Adapter Toolkit supports pluggable transport/parse/format modules written in Java
- API's for C/C++, Java, .NET

Operational Dashboards and UI options for streaming applications

- **Design Studio 1.4 and up** - includes support for visualization of streaming data, with connectivity to HANA streaming projects
- **HTML 5 (inc. SAP UI5)** - Standard REST interface and websocket support enables custom html5 applications (including SAP UI5) to receive/display streaming data



Resources

SAP HANA streaming analytics Developer Center

<https://developers.sap.com/topics/hana-streaming-analytics.html>



Thank you

Contact information:

Rob Waywell
SAP HANA Product Management

<https://developers.sap.com/topics/hana-streaming-analytics.html>