ScaleOut Software

ScaleOut Digital Twins™

Overview

March 2024

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About ScaleOut Software

ScaleOut Software

- Develops and markets software for **in-memory computing**:
  - Scales application performance and
  - Provides real-time analytical insights using
  - In-memory data storage, computing, stream processing, and simulation.
- Deep domain expertise:
  - Dr. William Bain, Founder & CEO. Bell Labs, Intel, Microsoft
  - Over 19 years in the market
  - Consistent track record of innovation and technology leadership
- Flexible business model to meet diverse needs:
  - Fully supported software releases
  - Dedicated to ease-of-use to minimize training and lower TCO
  - On-premise or cloud
  - Choice of licensing models: perpetual, subscription, cloud-hosted

Microsoft Partner
Silver Application Development

amazon web services Partner Network
TECHNOLOGY PARTNER

Windows Azure

cloudera CERTIFIED

Gartner 2015
Cool Vendor

ScaleOut Digital Twins

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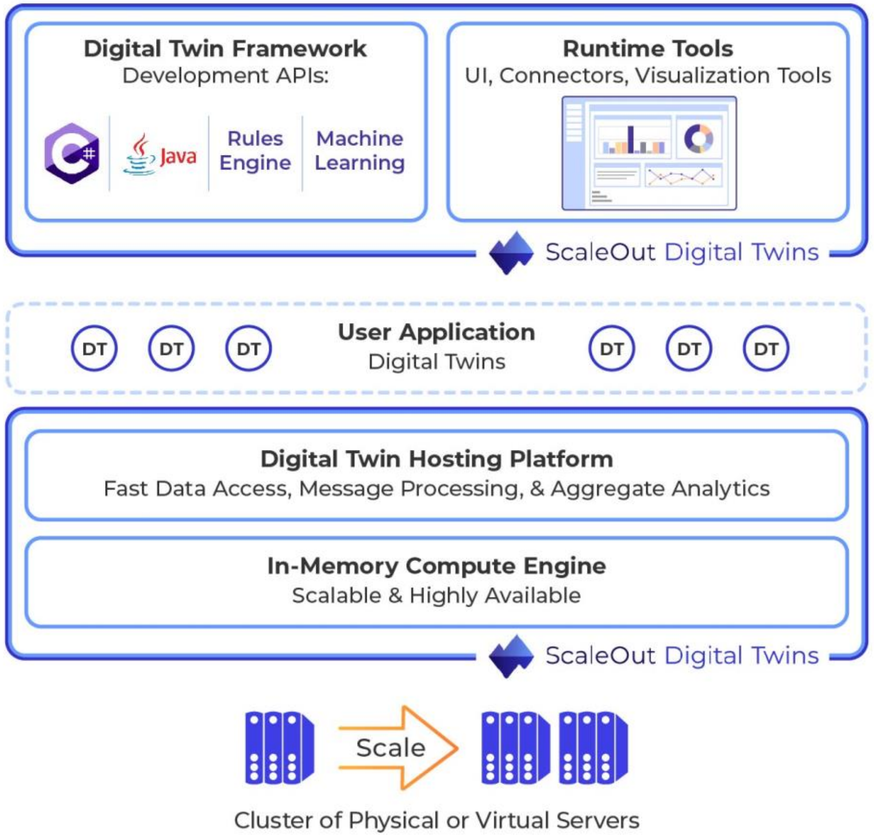
Real-Time Monitoring and Predictive Modeling with Digital Twins

A software framework for building digital twin applications and a fast, scalable hosting platform:

- Runs in the Azure cloud or on-premises
- Includes development tools in C#, Java, using business rules and machine learning.
- Hosts digital twins on ScaleOut's patented, in-memory computing platform.
- Has a UI for control, query, and visualization of aggregate analytics.
- Connects to messaging hubs, Kafka, REST, alerting services, database servers, and more.



Challenge: Power Grid Security & Disaster Response

How track a geographically distributed power grid with thousands of nodes for intrusion or disruption?

- Where are the threats?
- How significant are they?
- How are they moving?
- How should we react?

Challenge: Logistics & Telematics

How track the safe distribution and delivery of millions of time-critical items?

- Where is each item/vehicle right now?
- How are delays or issues (e.g. temperature) affecting its safety?
- Which vehicles are most in need of assistance?
- Is there an emerging widescale problem that needs a strategic response?

A New Vision for Digital Twins

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> *A digital twin is a virtual representation of real-world entities and processes, synchronized at a specified frequency and fidelity. … Digital twins use real-time and historical data to represent the past and present and simulate predicted futures. …   -- as defined by the Digital Twin Consortium*

- Digital twins were conceived to help design and test complex new devices (PLM).
- More recently, operational digital twins are used in small numbers to track telemetry in production for preventative maintenance.
- The next step: use digital twins for **real-time monitoring** and **predictive modeling** of large systems:
  - Vehicle fleets
  - Logistics systems
  - Large infrastructures
  - Ecommerce shoppers

Designing a Jet Engine

Monitoring an Industrial Robot

Tracking the US Railway System

The Need for Granular Real-Time Analytics

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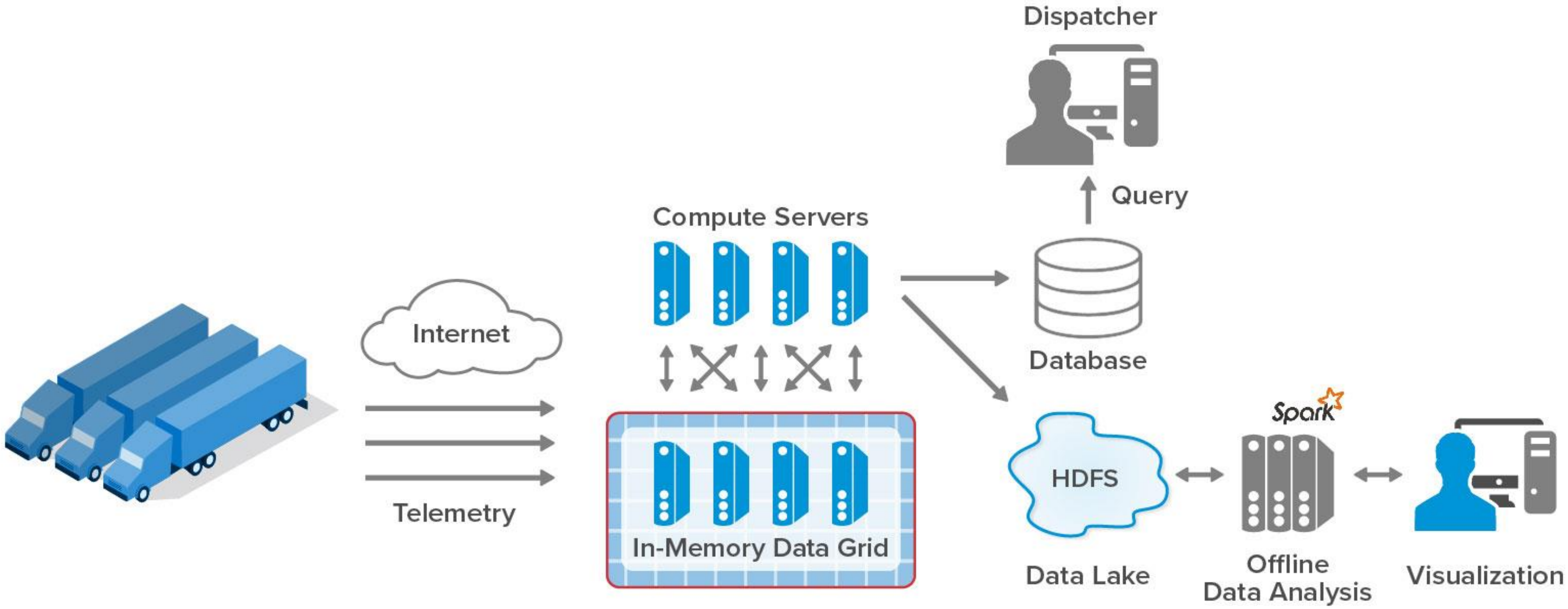
Today's streaming analytics do not:

- Track data sources *individually*.
- Perform aggregate analytics online.

As a result, they cannot:

- Predict emerging issues for each data source.
- See important trends in real time (seconds).



Typical Telematics Architecture for Streaming Analytics

The Solution: Real-Time Digital Twins

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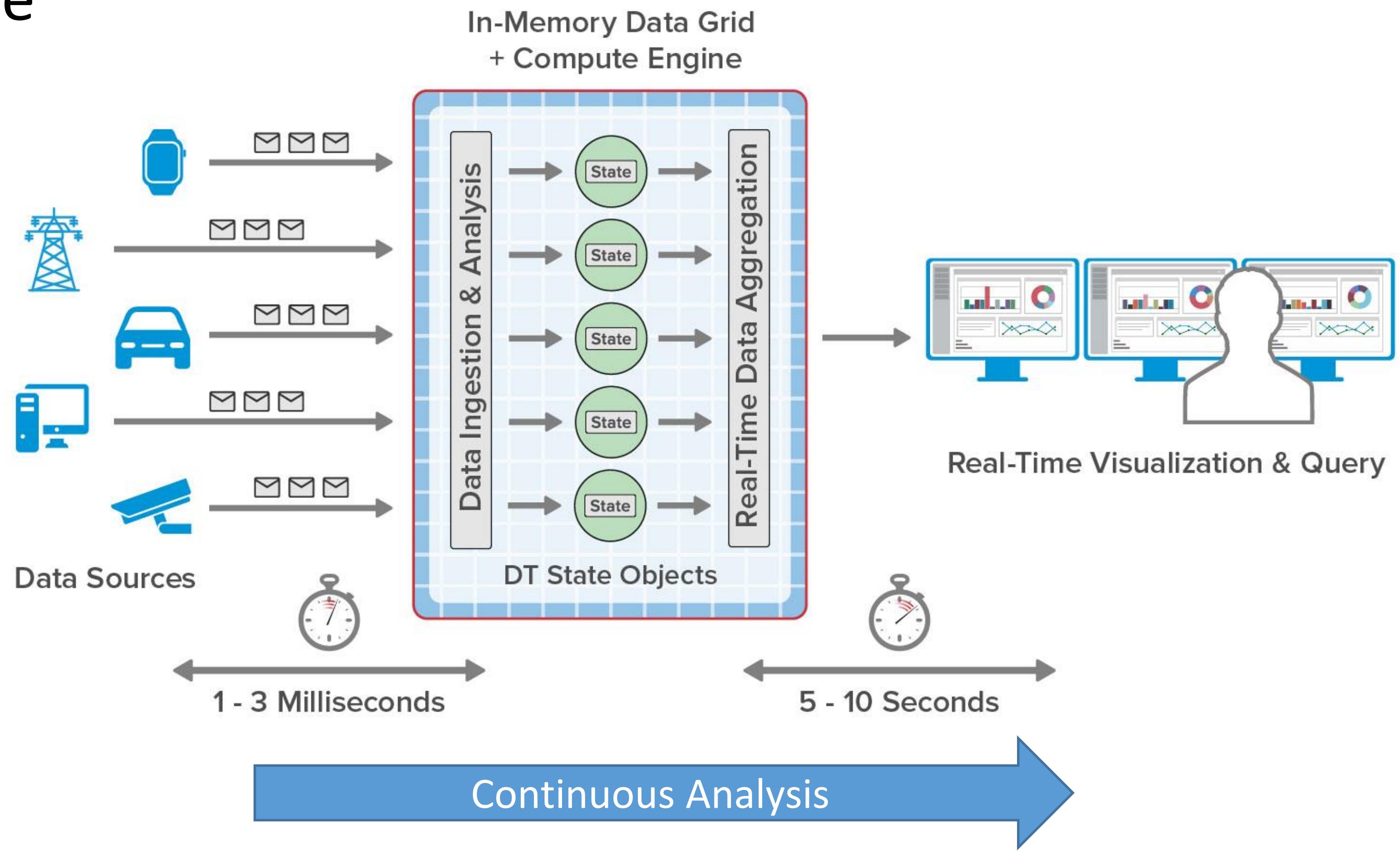
A new in-memory technique for streaming analytics:

- Separately analyzes telemetry for *each* data source.
- Maintains dynamic state for each data source.

Key Advantages:

- Introspects in real time on *each* data source.
- Provides data for immediate aggregate analytics.
- Transparently scales.



Software Architecture Using Real-Time Digital Twins

Benefits of Real-Time Digital Twins

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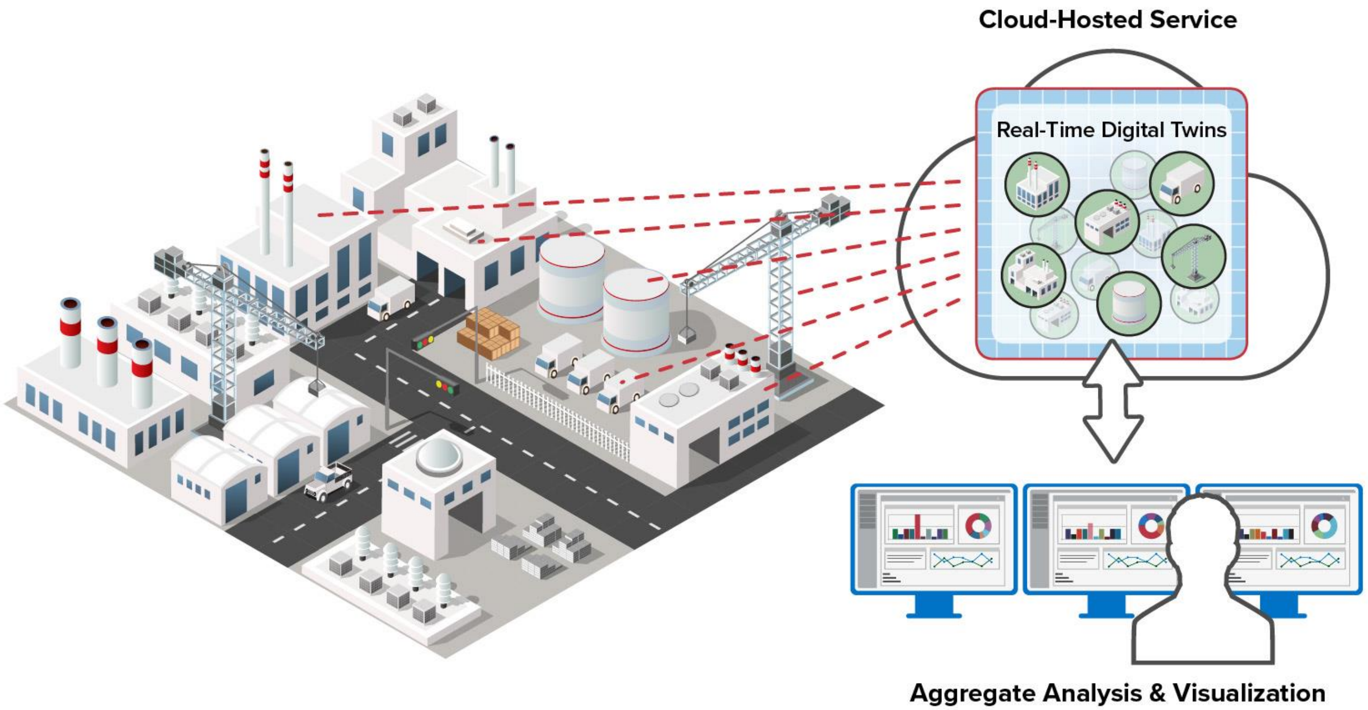
- **Faster responses**: Continuously analyzes incoming telemetry.
- **Deeper introspection**: Tracks and updates information about each data source.
- **Better situational awareness**: Continuously aggregates & visualizes derived state.
- **Transparently scalable**: Seamlessly scales using in-memory computing.
- **Easy to use**: Uses simple, object-oriented APIs.



Comparison to Conventional Techniques

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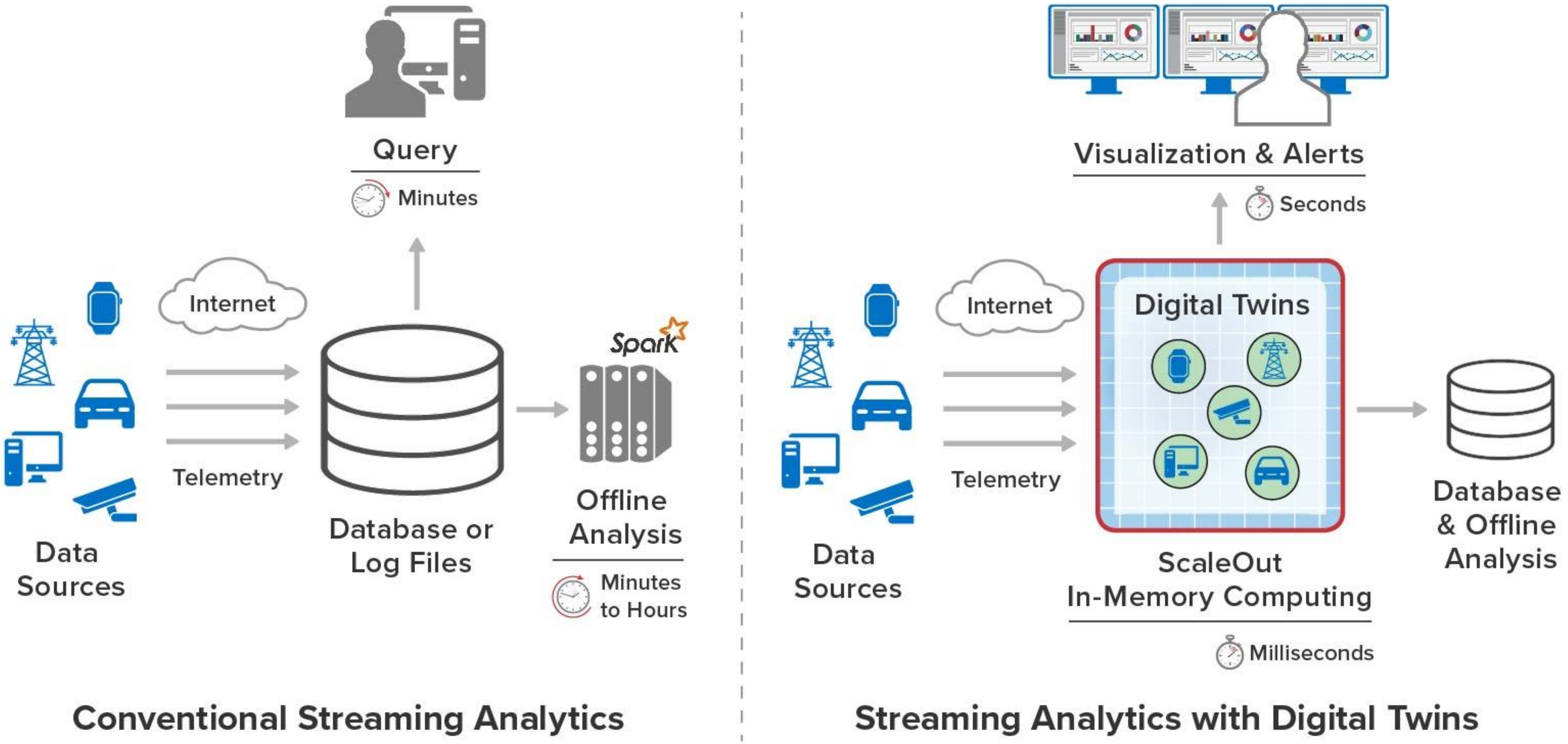
Real-time digital twins immediately extract useful information, generate alerts, and visualize emerging trends:



Digital Twins Enable Aggregate Analysis

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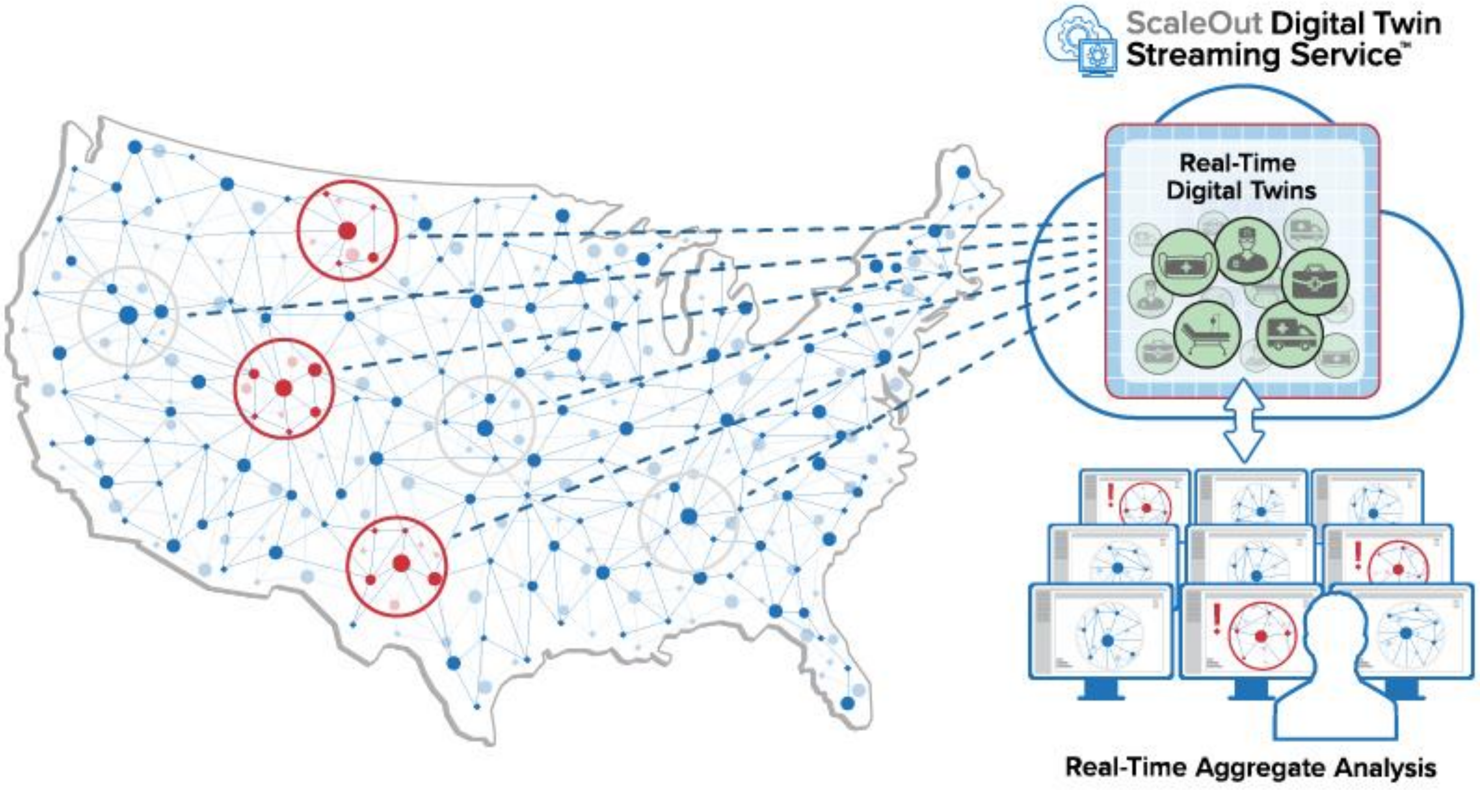
- **Simultaneously** analyzes all real-time digital twin instances to identify and visualize widespread trends in real time.
- Boosts **situational awareness**.
- Some examples:
  - Offer flash sale to individual online shoppers *and* tweak it in real time by tracking overall impact.
  - Monitor power stations *and* identify rolling blackout.
  - Track a rental car fleet *and* alert all drivers vehicles approaching an unplanned road closure.
  - Identify an emerging pattern of fraudulent wire transfers.



Example of Aggregate Analytics & Query

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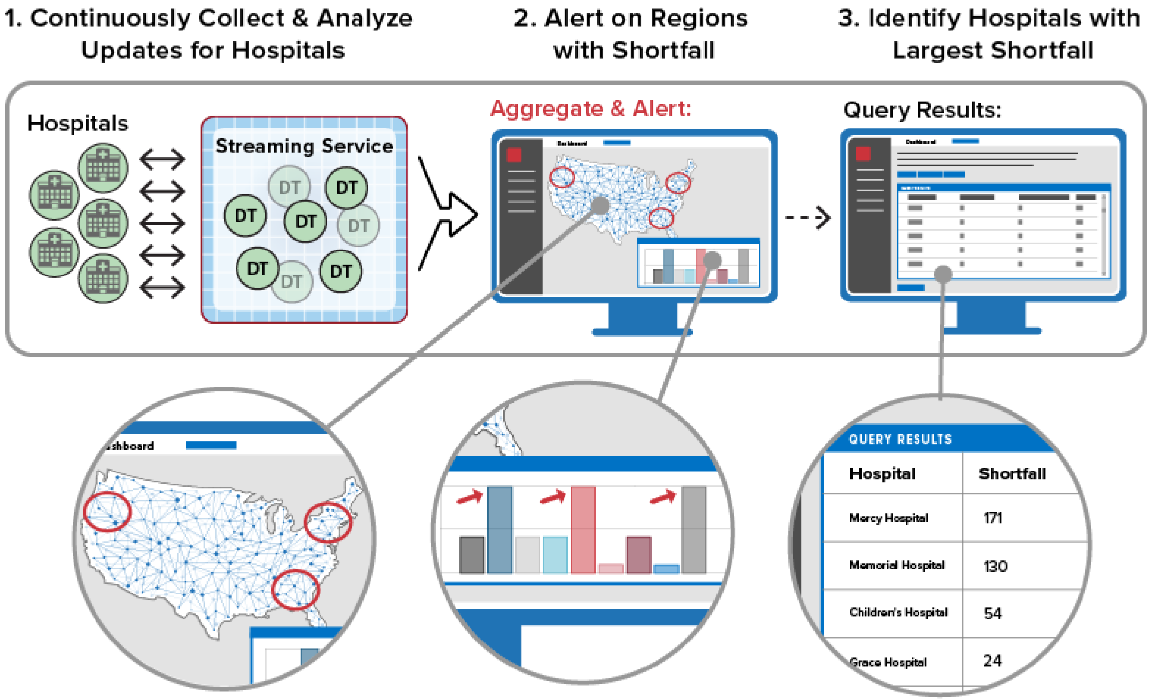
Maximizes situational awareness for a logistics application:

- Integrated analytics engine combines key digital twin data in seconds.
    - Example: Determine largest shortfall in hospital supplies by region.
- Streaming service lets users visualize results.
    - Example: Show shortfall by region as a bar chart to alert on problem areas as they occur.
- Users query digital twin data to identify issues and take action.
    - Example: Query digital twins to find specific hospitals with largest shortfall in affected regions.



Using Digital Twins for Simulation

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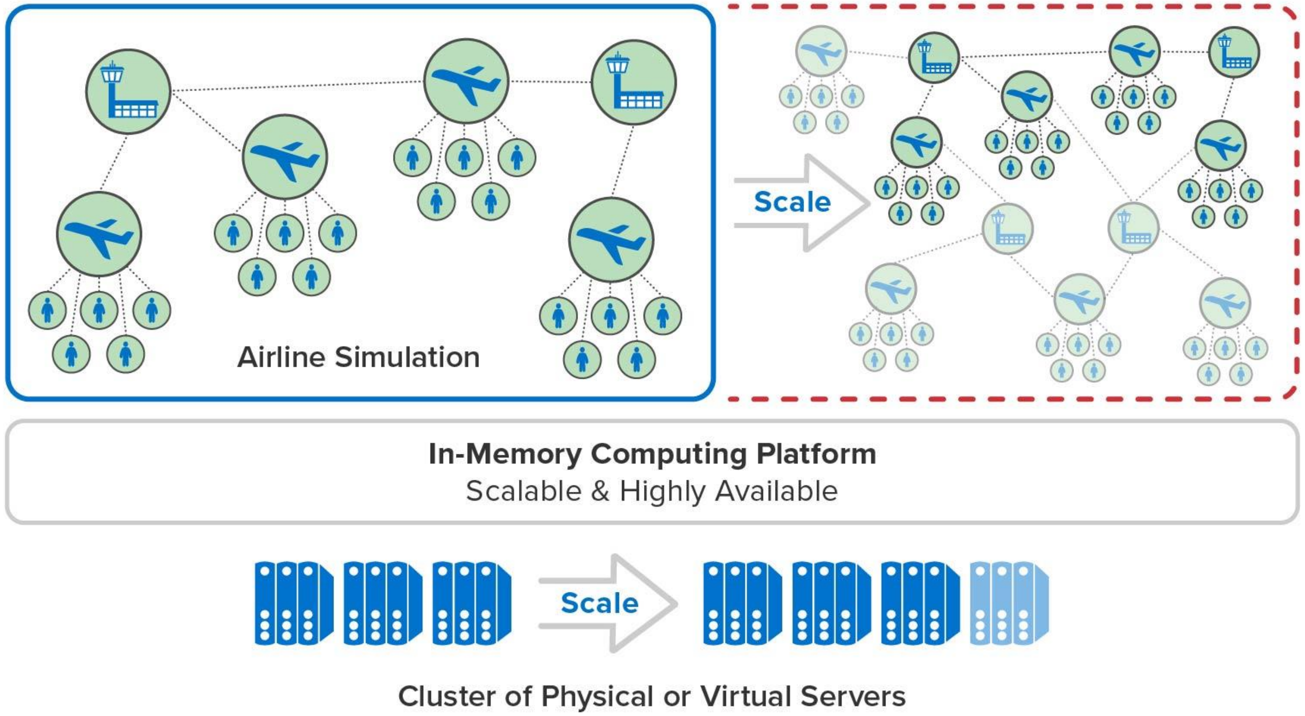
Digital twins:

- Enable the construction of large-scale simulations (1000s to millions of interacting entities).
- Simplify simulation development.

Key benefits:

- **Improved decision making** for managing complex systems.
- Ability to **make predictions** for *live* systems.
- **Testing and validation** for streaming analytics.



Airline Simulation

Using Simulation to Validate Streaming Analytics

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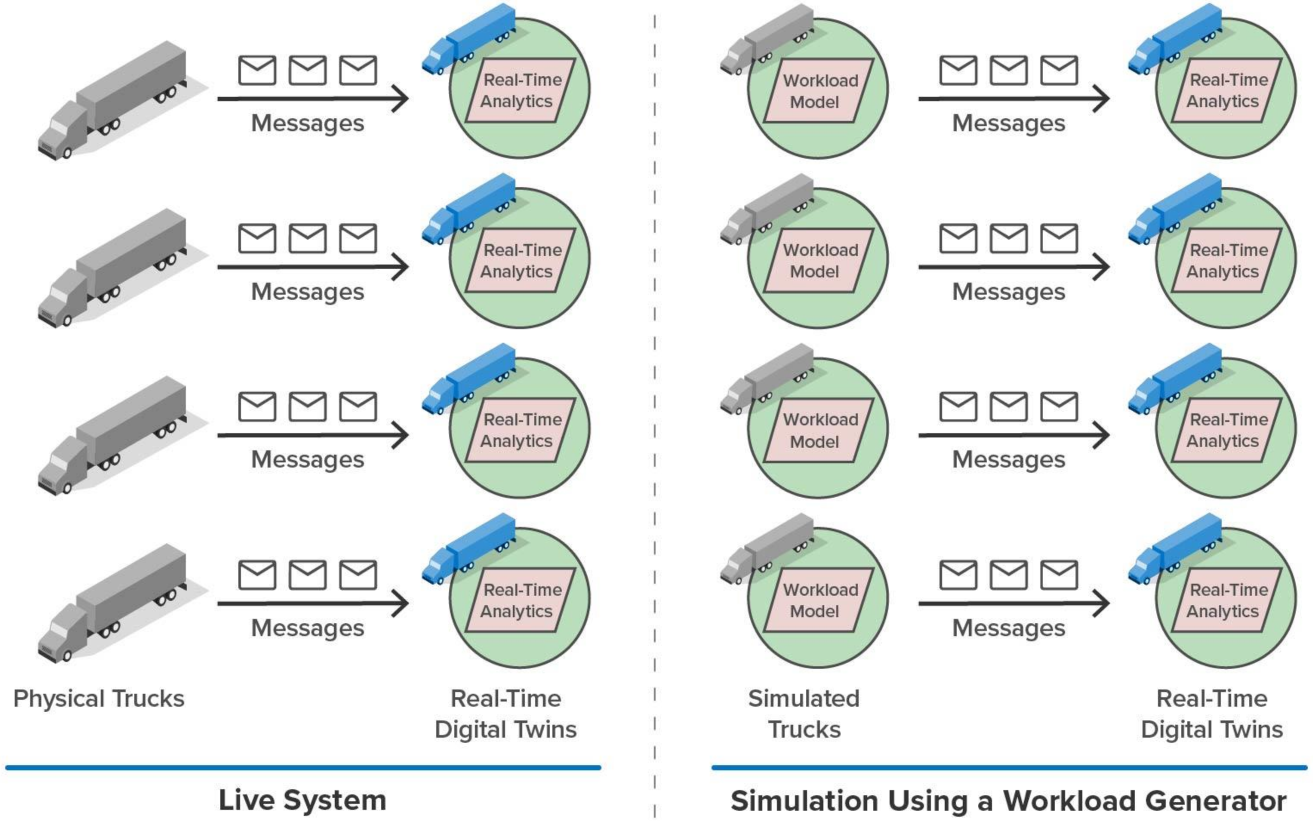
- Digital twins can model live data sources:
  - Generate telemetry in simulation and send it to real-time digital twins.
  - Real-time digital twins can implement streaming analytics.
- Simulation validates streaming analytics in a variety of scenarios.
- Real-time digital twins can then be deployed to analyze live telemetry.



Telematics Simulation

Many Use Cases

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Here are some use cases for digital twins tracking and modeling complex live systems:

- Telematics – vehicle fleets
- Transportation safety – railroads
- Transportation systems – help manage passengers and assets for an airline
- Logistics –tracking shipments
- Disaster recovery –tracking wildfires and alerting personnel
- Security – tracking physical and cyber security perimeters
- Crime prevention – cloned license plate and convoy detection
- Fraud detection – credit card fraud
- Health informatics – tracking with wearable devices
- Smart cities and building management

Example: Fleet Telematics

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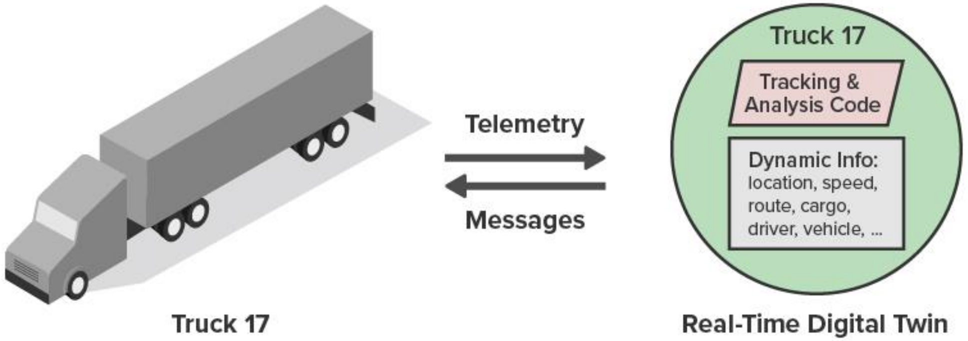
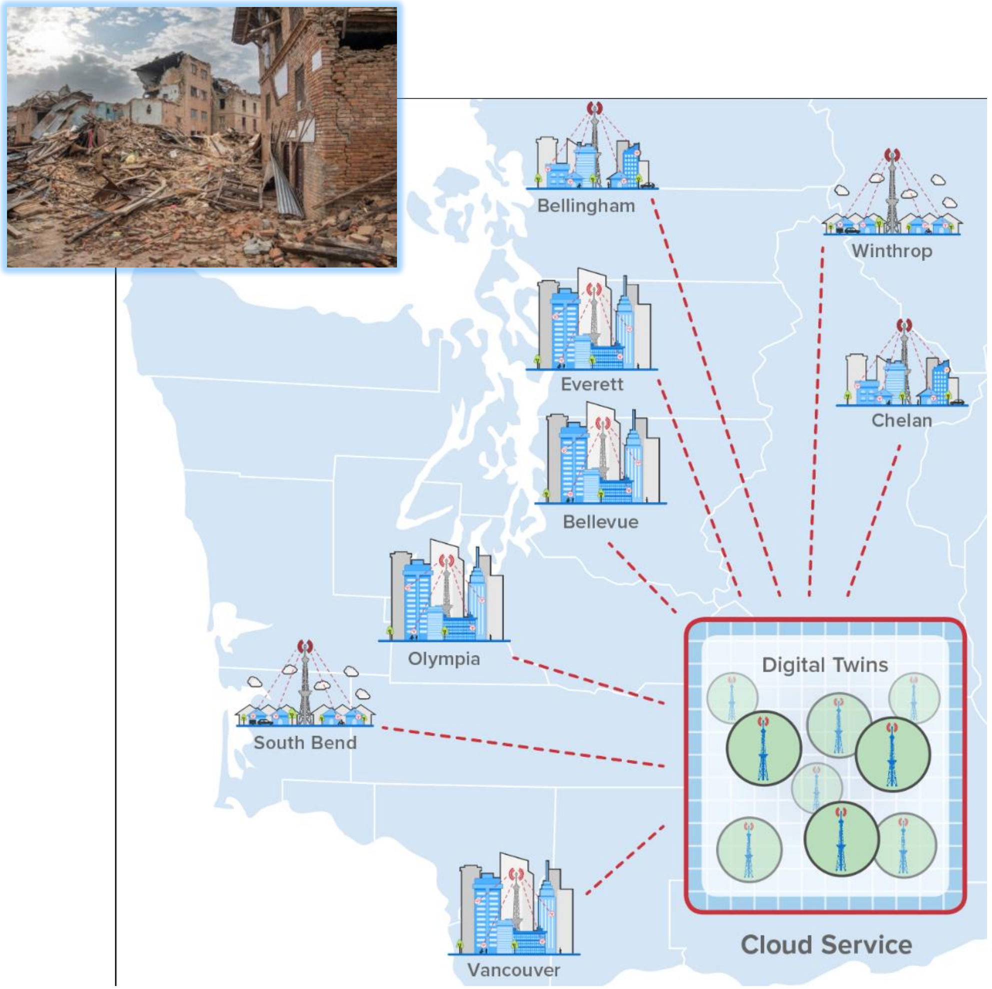
- Real-time tracking for a car/truck fleet (typically, thousands of vehicles)
- Telemetry includes location, speed, mechanical & cargo parameters.
- Digital twins add route, cargo, info on driver, service history & issues, weather, etc.
- Using incoming telemetry, digital twins can:
  - Alert driver to upcoming hazardous road conditions or weather delays.
  - Assist lost driver or alert if driving too long or unsafely.
  - Track emerging mechanical issues with vehicle or risk to cargo.
  - Maintain status which can be aggregated for all trucks to enhance dispatcher's situational awareness of the fleet.



Example: Disaster Recovery

- Goal: help find buried survivors after an earthquake using their cell phone data.
- How?
  - 5G cell towers can track direction and signal strength for each subscriber.
  - This information can help locate survivors.
- There are about 350K 5G cell sites in the U.S.
- Digital twins can maintain current status of all cell towers.
  - Can track fast-changing updates to call status for each cell tower.
  - Aggregate analytics can immediately pinpoint areas of greatest need.



Example: Tracking the Freight Rail System

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- Each year in the US, thousands of freight trains carry 1.6 billion tons of freight across 140,000 miles of track:
    - Approx. 300 trains per week
    - Approx 500K carloads per week
- In 2022, there were more than 1,100 train derailments, causing over 100 million dollars in damage.
- 6,000 hot boxes around the US monitor the temperature of wheel bearings, which can cause derailments if they get too hot.
- Hot boxes just alert operators by radio when high temperature is detected; they do not track trends.
- Digital twins can solve this problem:
    - Track and analyze temperature trends for all wheel bearings.
    - Integrate service history and other relevant data to assess danger and create timely alerts.

July 28, 2023

Example: Managing Airline Operations

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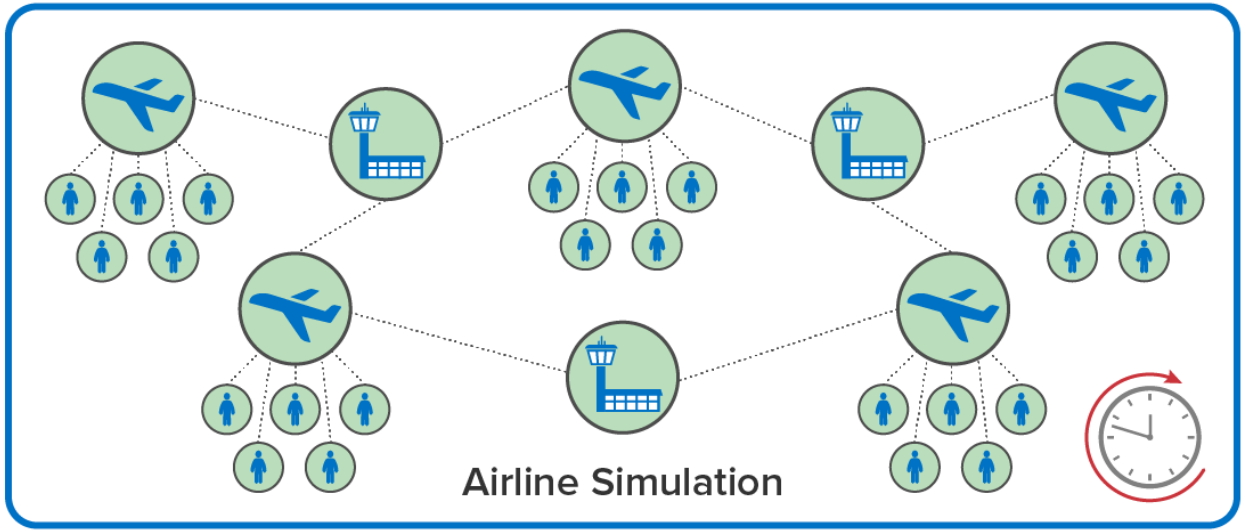
Build **system simulations** with interacting digital twins exchanging messages for performance evaluation & prediction.

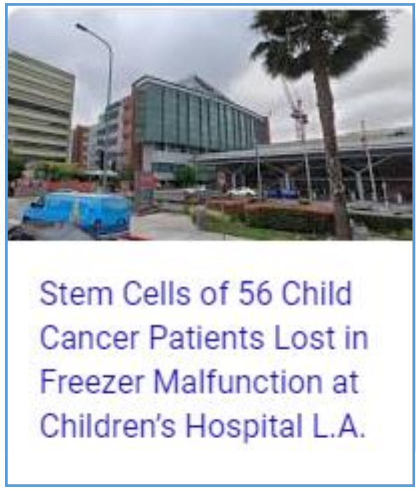
- Use digital twins to model physical entities:
  - Airplanes, passengers
  - Airports, gates, etc.
- Model and measure complex interactions.
- Evaluate management decisions faster than real time.
- Enable improved flying experience.



Example: Medical Refrigerators

- Cloud-based streaming service monitors 10,000+ medical refrigerators:
- Refrigerators hold highly important tissue samples, embryos, etc.
- Service receives periodic telemetry:
  - Temperature
  - Power consumption
  - Door position, etc.
- Must predict failure before it occurs:
  - Notify user to migrate contents to another refrigerator.
  - Avoid false positives.
  - Identify widespread power outages (aggregate analytics).

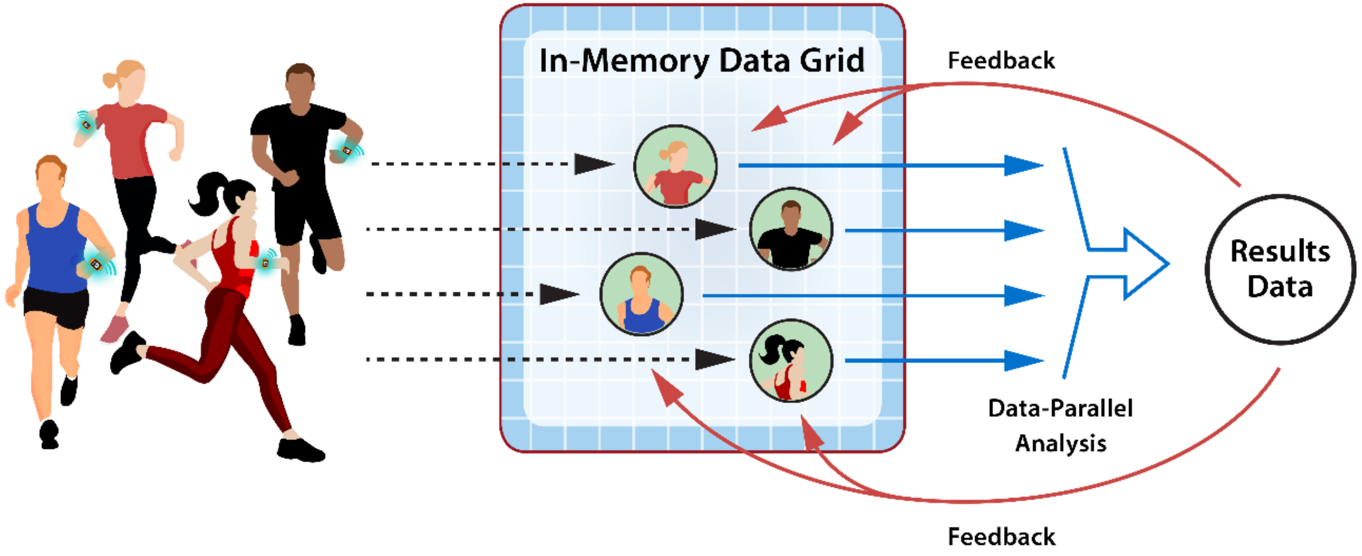
Sep 26, 2019



Example: Personalized Health Tracking

Real-time digital twins analyze telemetry from health-tracking devices to help ensure wearer's safety and give feedback:

- RTDTs receive periodic messages with key metrics (heart rate, blood oxygen, etc.).
- RTDTs track person's health history, medications, limitations, recent medical events.
- Data-parallel analysis combines dynamic results from large populations for feedback.



Example: Cybersecurity

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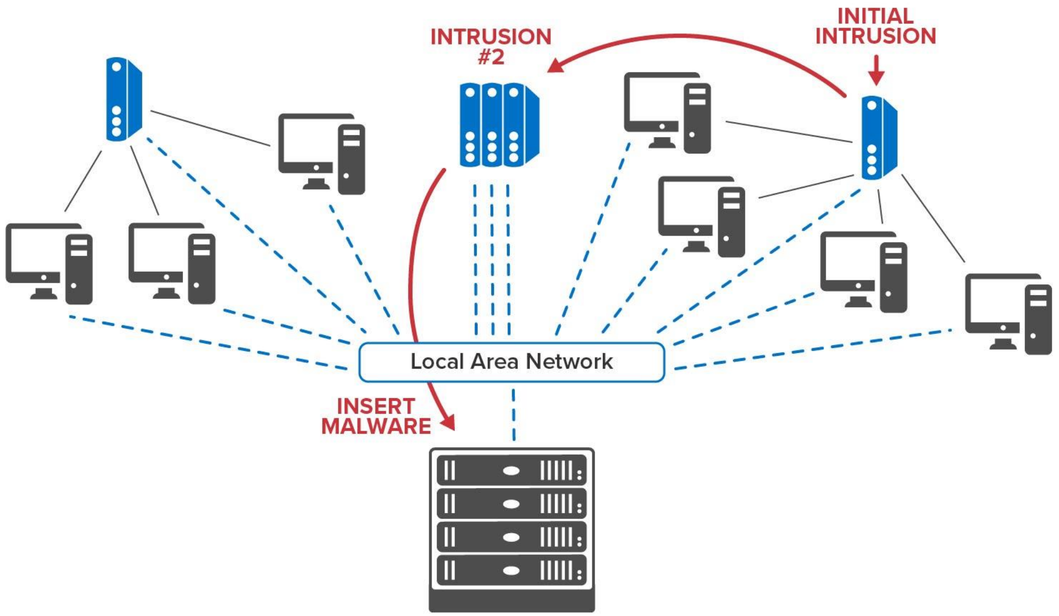
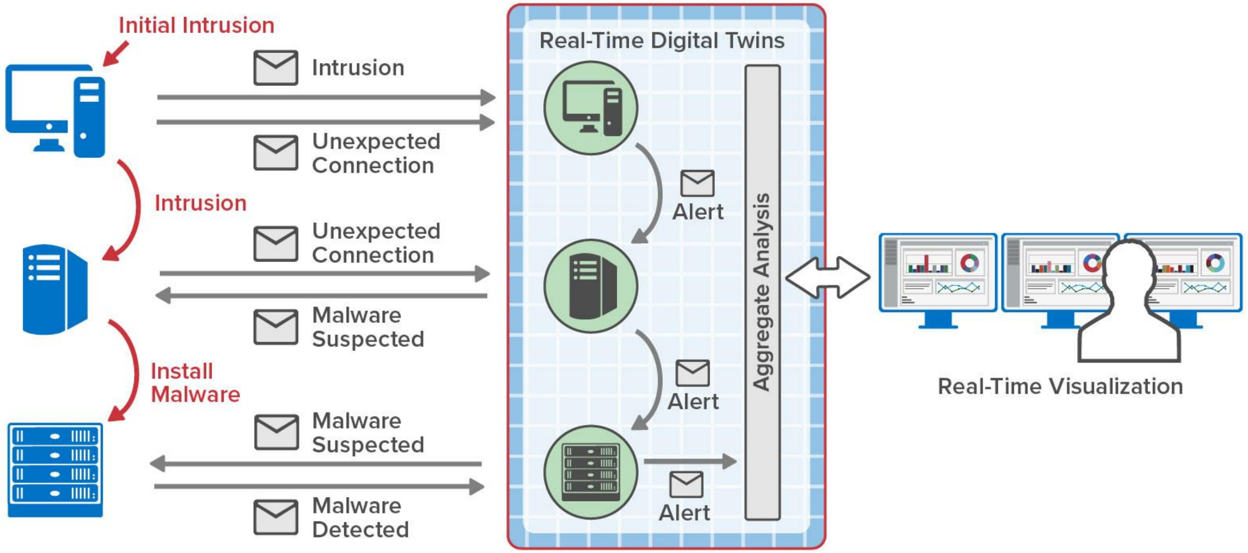
- Real-time digital twins can be used to:
  - Track the evolving state of entry points and assets (e.g., desktops, routers, servers).
  - Display the dynamic state of assets, not just events in SIEM consoles.
  - Track (with ML) and possibly stop the progress of an intruder within an infrastructure.



Example of a Cyber “Kill Chain”



Use of RTDTs to Interrupt Intruder’s Progress

Demo: Simulated Power Grid

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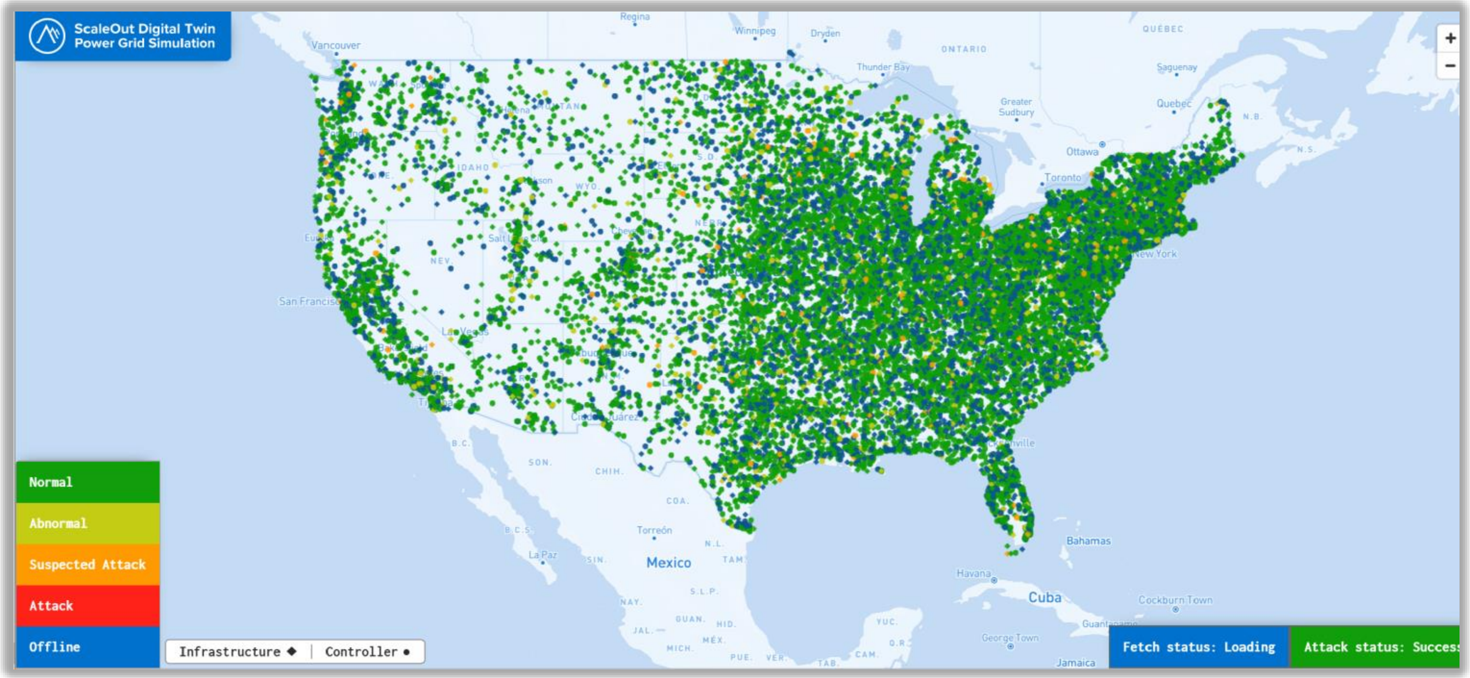
- **Goal**: **Demonstrate value of enhanced situational awareness**
- **Overview**:
  - Simulates 20K nodes within a power grid spanning the US and subject to outages or attack.
  - Each node streams telemetry with its status to its real-time digital twin in the cloud service.
  - Real-time twin evaluates telemetry and updates derived state: *alert level*:
    - Assesses threat level for that node (range 0-20)
    - Updated by examining telemetry with knowledge of node's function and reporting history (e.g., false positives)



Demo: Aggregate Analytics

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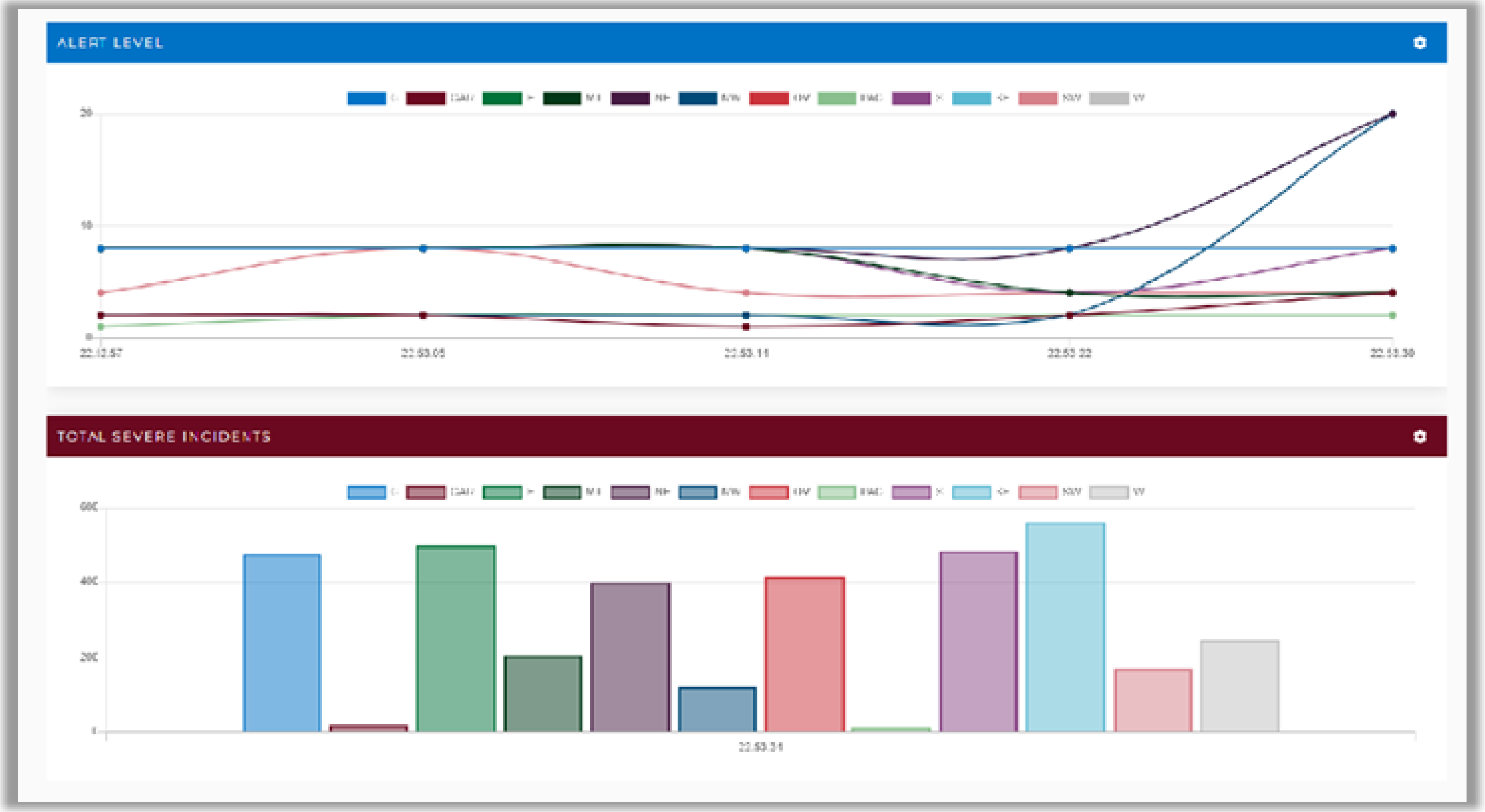
Aggregate analysis by the cloud service quickly pinpoints emerging threats for managers:

- Evaluates alert level in digital twin state for all nodes and aggregates results.
- Dashboard widgets display maximum alert level by region.
- Runs every 5-10 seconds as a background MapReduce job.



Anatomy of a Digital Twin

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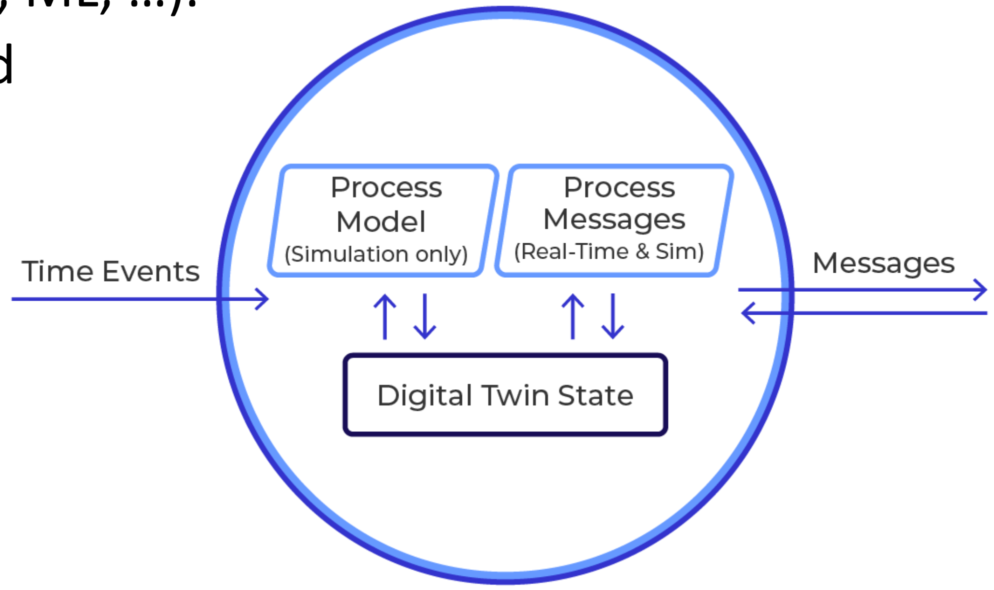
A **digital twin model** It consists of a:provides integrated support for both streaming analytics and simulation. For each device type, it consists of:

- A **message processing** and optional **simulation processing method**:
  - Receives and analyzes live or simulated messages and simulation time events.
  - Encapsulates analysis algorithm (Java, C#, rules, ML, …).
  - Updates state information, generates outbound messages and alerts.
- A **state object**, which holds dynamic data:
  - Context/metadata for analyzing events
  - Also: time-ordered event lists, cached parameters
  - One **instance** per data source or device



ScaleOut Digital Twin Model

Simplified Development + High Performance

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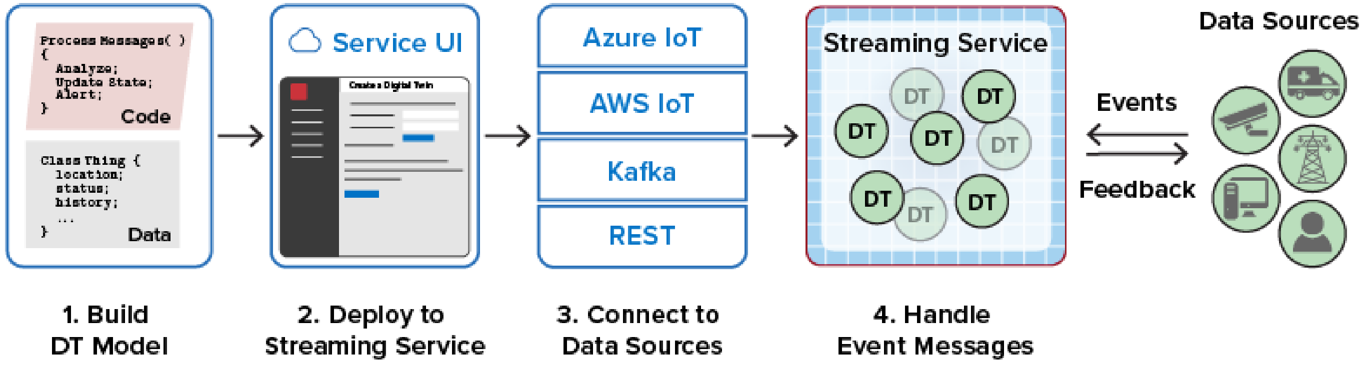
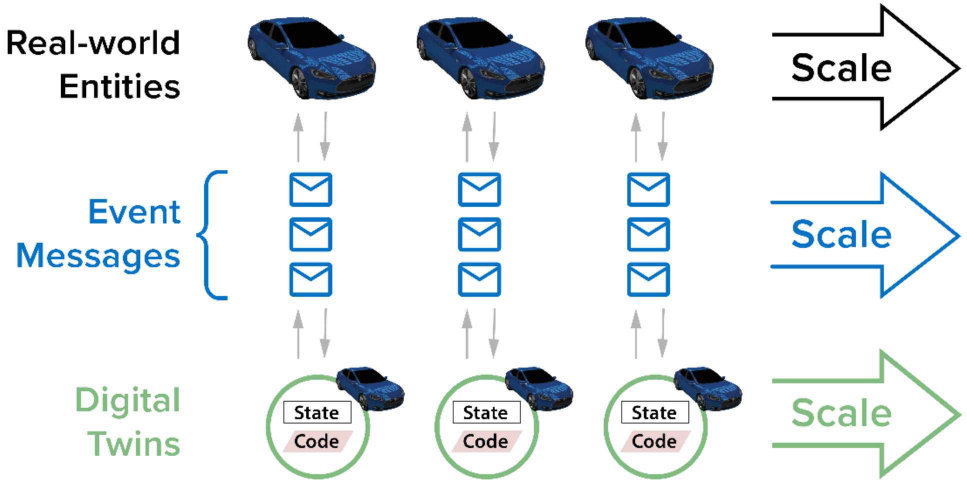
Enables easy-to-build, "agile" applications.

- Digital twin model minimizes code development:



- Streaming service handles scaling and ensures high availability:



Implementing Digital Twin Simulations

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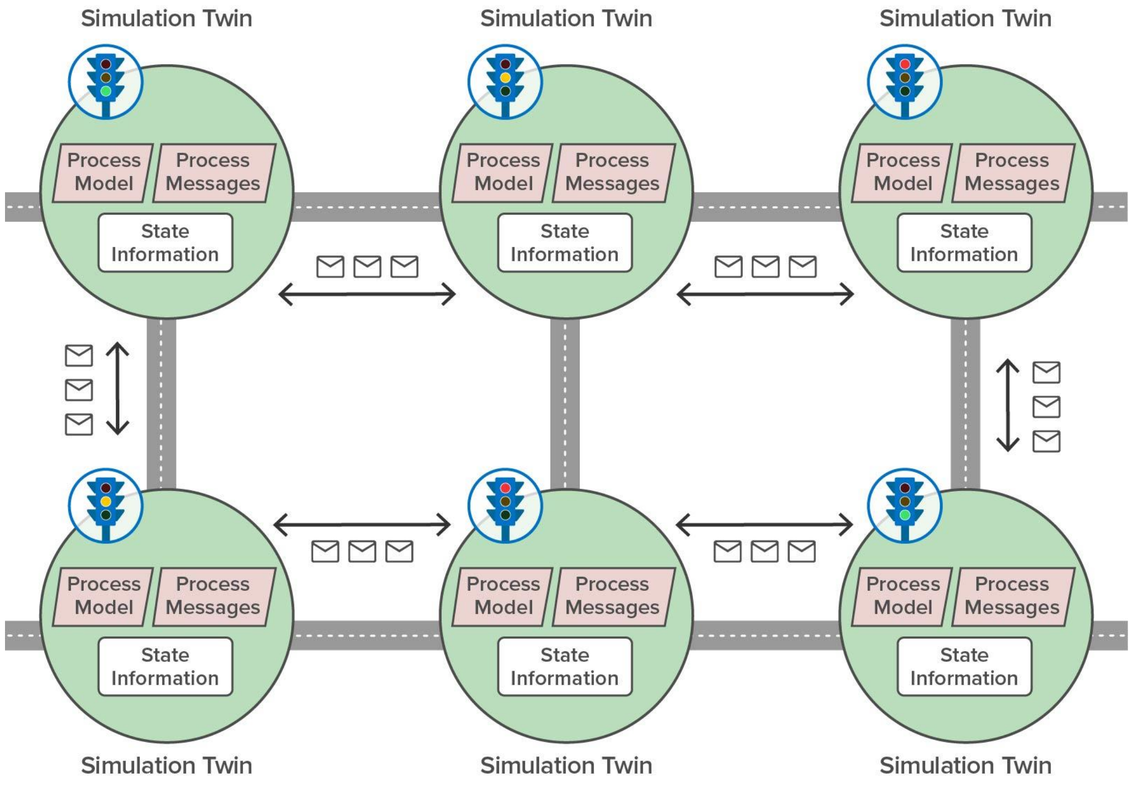
- User's digital twin model implements:
  - State information to be maintained by each instance
  - A ProcessModel method that runs at each time step
  - A ProcessMessages method that handles incoming messages
- ScaleOut's in-memory platform:
  - Distributes digital twin instances across a server cluster.
  - Runs all instances at each time step.
  - Delivers and processes messages sent between instances.
  - Provides data visualization and query.



A Traffic-Flow Simulation

Development Workbench

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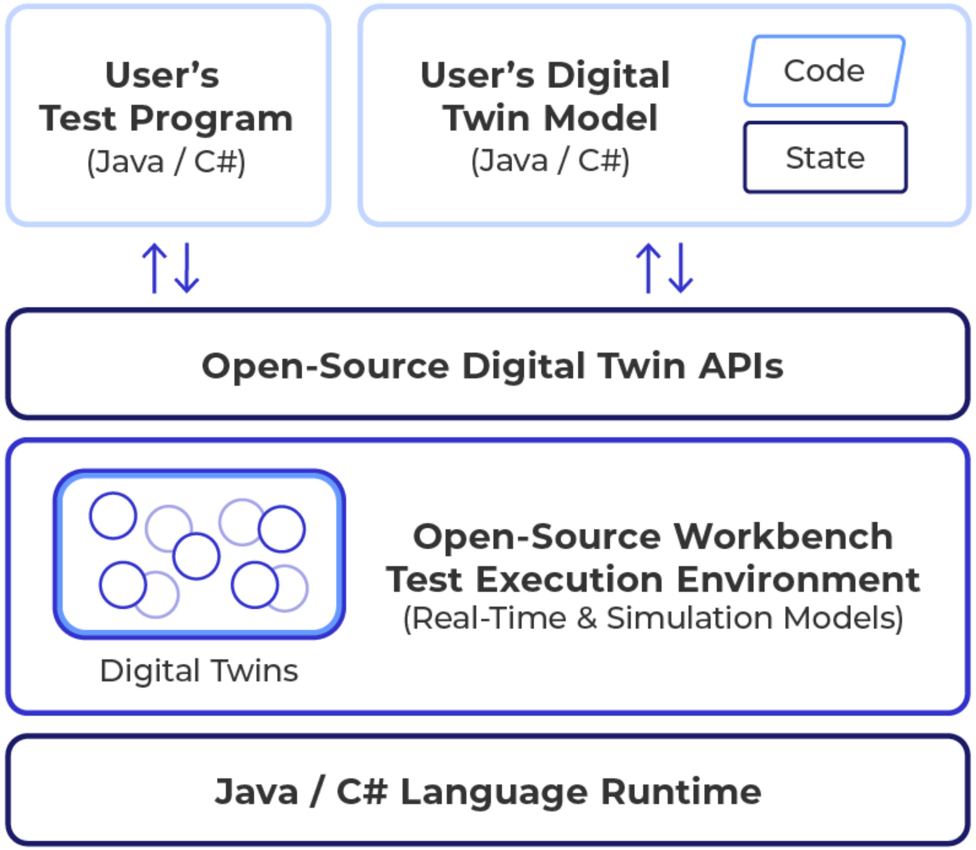
- Debugging and test within the cloud service can be challenging.
  - Cannot set breakpoints and examine state.
  - Difficult to verify all code paths.
- Workbench environment allows development and test on developer's workstation:
  - Uses same base classes as production deployment.
  - Replaces `ProcessingContext` with mock version.
  - Deploys model with same APIs as used on-premises.
  - Allows sending/receiving messages from instances.
  - Allows instance state to be examined.



Optional Rules Engine Simplifies Design

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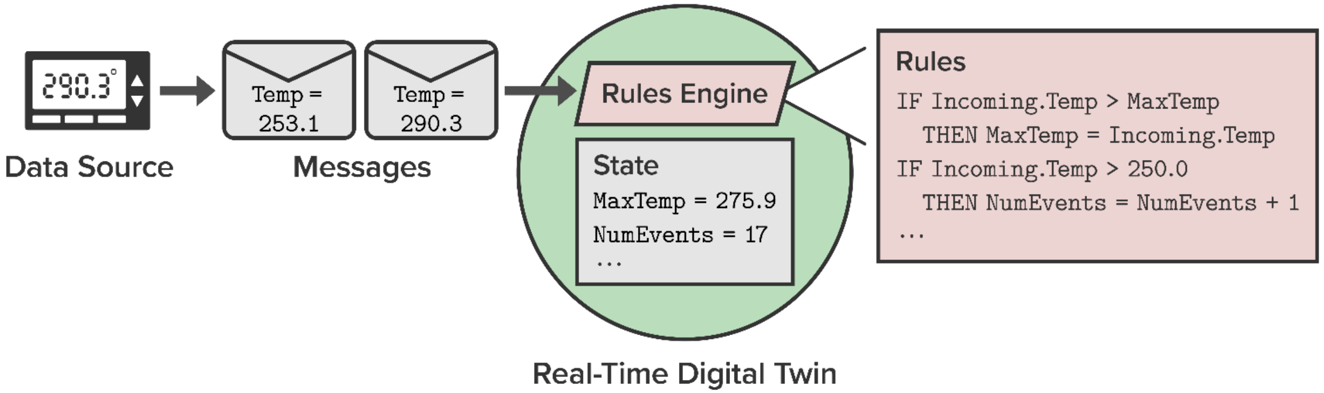
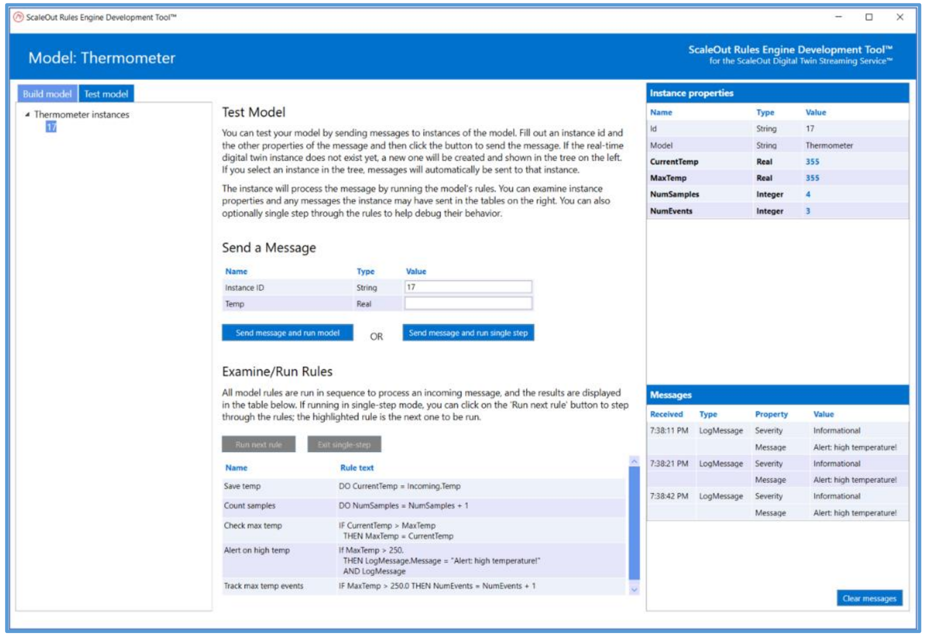
- Allows application code to be described as a sequence of rules:
  - Uses a simple "IF condition THEN action" rules language.
  - Avoids the need to use formal programming languages.

- Desktop-based **ScaleOut Model Development Tool** enables fast development and testing.





Optional Machine Learning Adds Power

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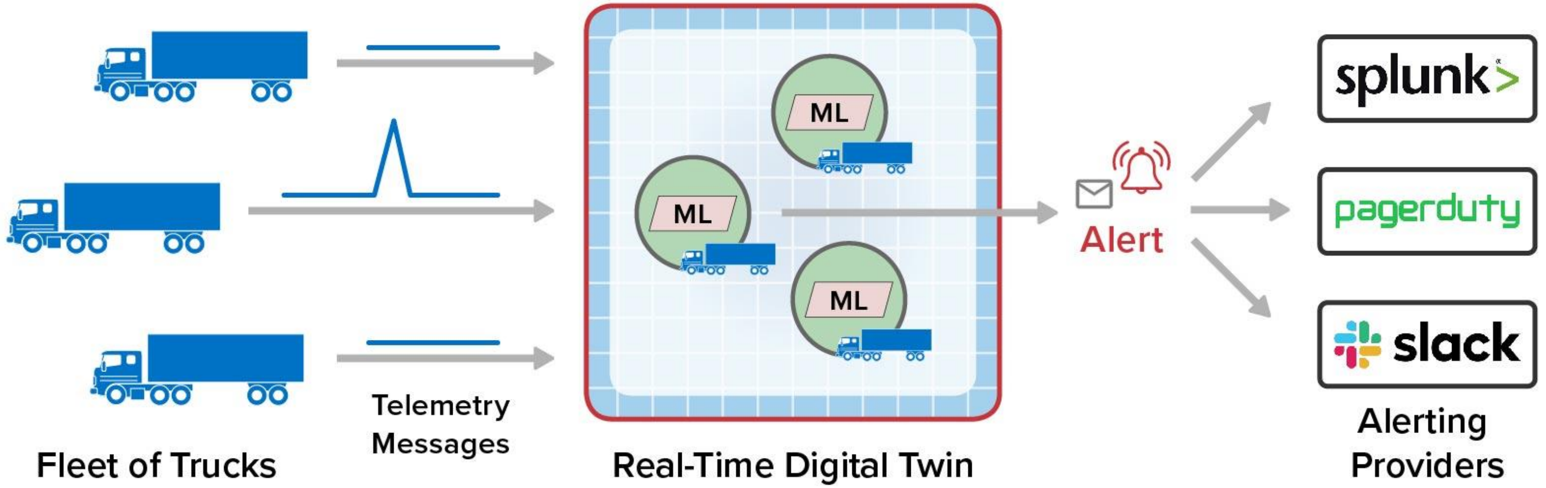
Digital twins can run machine learning algorithms from Microsoft ML.NET library to analyze telemetry from data sources:

- Performs spike, trend, and anomaly detection and send alerts with **no code required**.
- Runs separately for each data source in each real-time digital twin.
- Can be integrated with rules for additional analysis.



Machine Learning Capabilities

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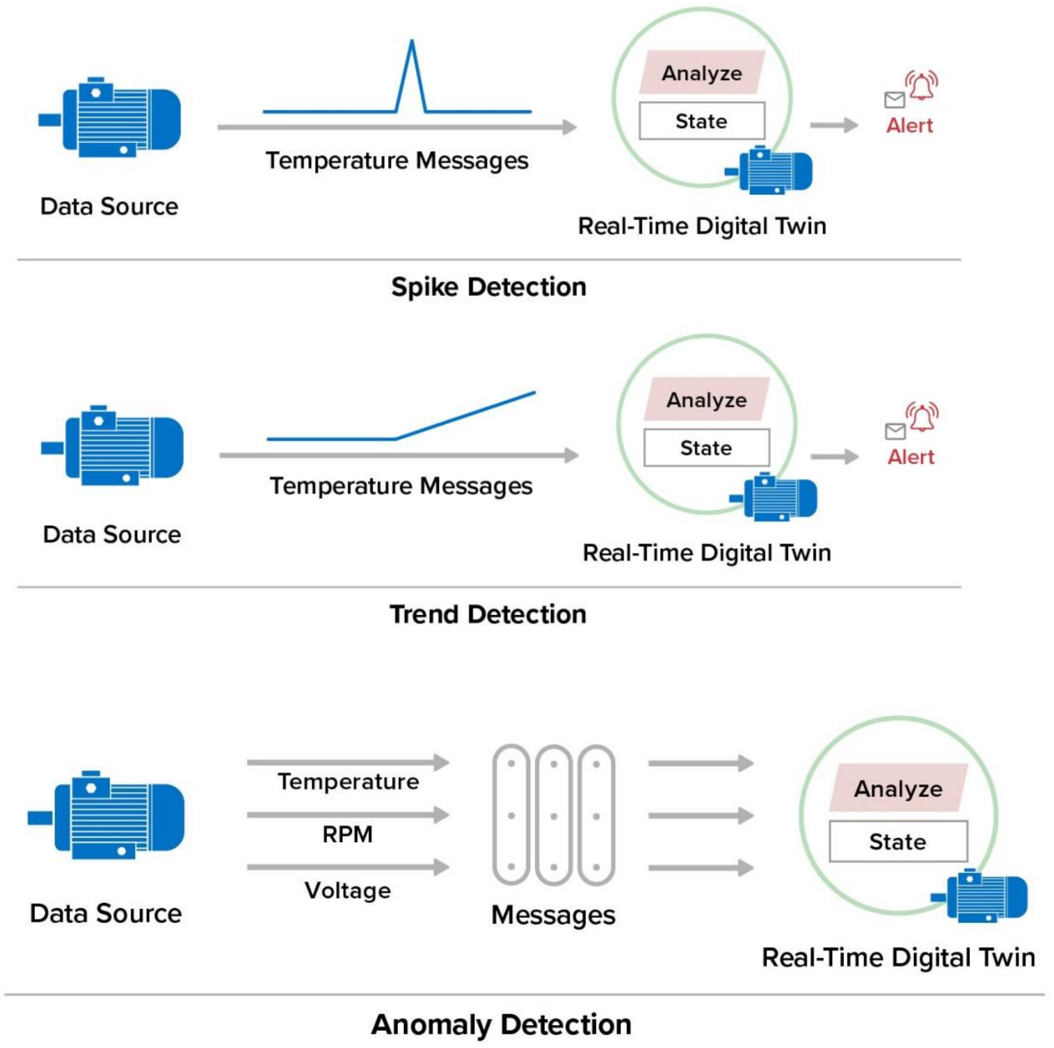
Automatic spike, trend, and multi-parameter anomaly detection:

- Spike and anomaly detection use ML.NET.
- Trend detection uses ScaleOut linear regression algorithm.
- User configures with ScaleOut Model Development Tool.



Training Anomaly Detection

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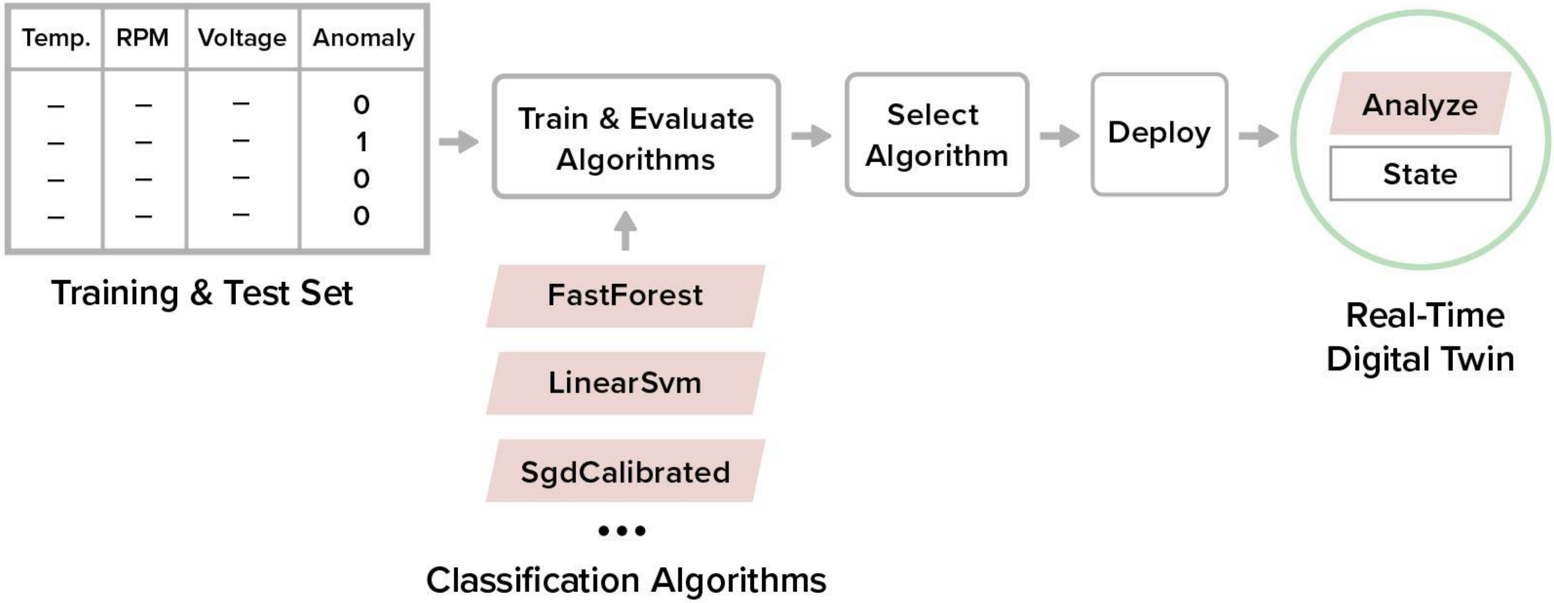
Anomaly detection uses binary classification algorithm trained with user's data set:

- User can train multiple algorithms from ML.NET.
- User selects one algorithm based on metrics from training.



Workflow for Training Real-Time Digital Twin Model

Optional Azure Digital Twins Integration

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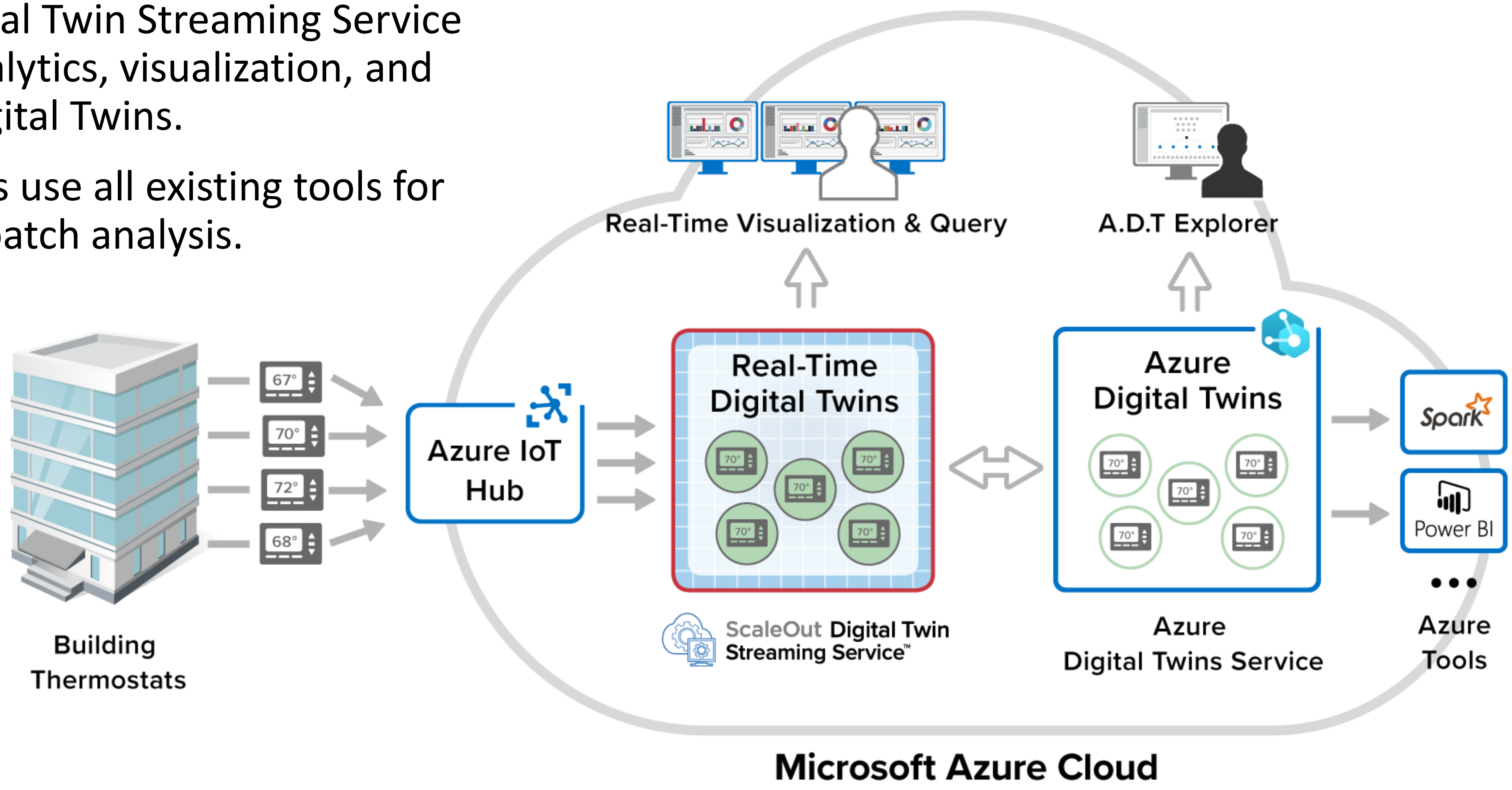
- The ScaleOut Digital Twin Streaming Service adds real-time analytics, visualization, and query to Azure Digital Twins.
- Azure Digital Twins use all existing tools for visualization and batch analysis.



Thermostat Example Running in the Azure Digital Twins Ecosystem

Transparent Migration to the Edge

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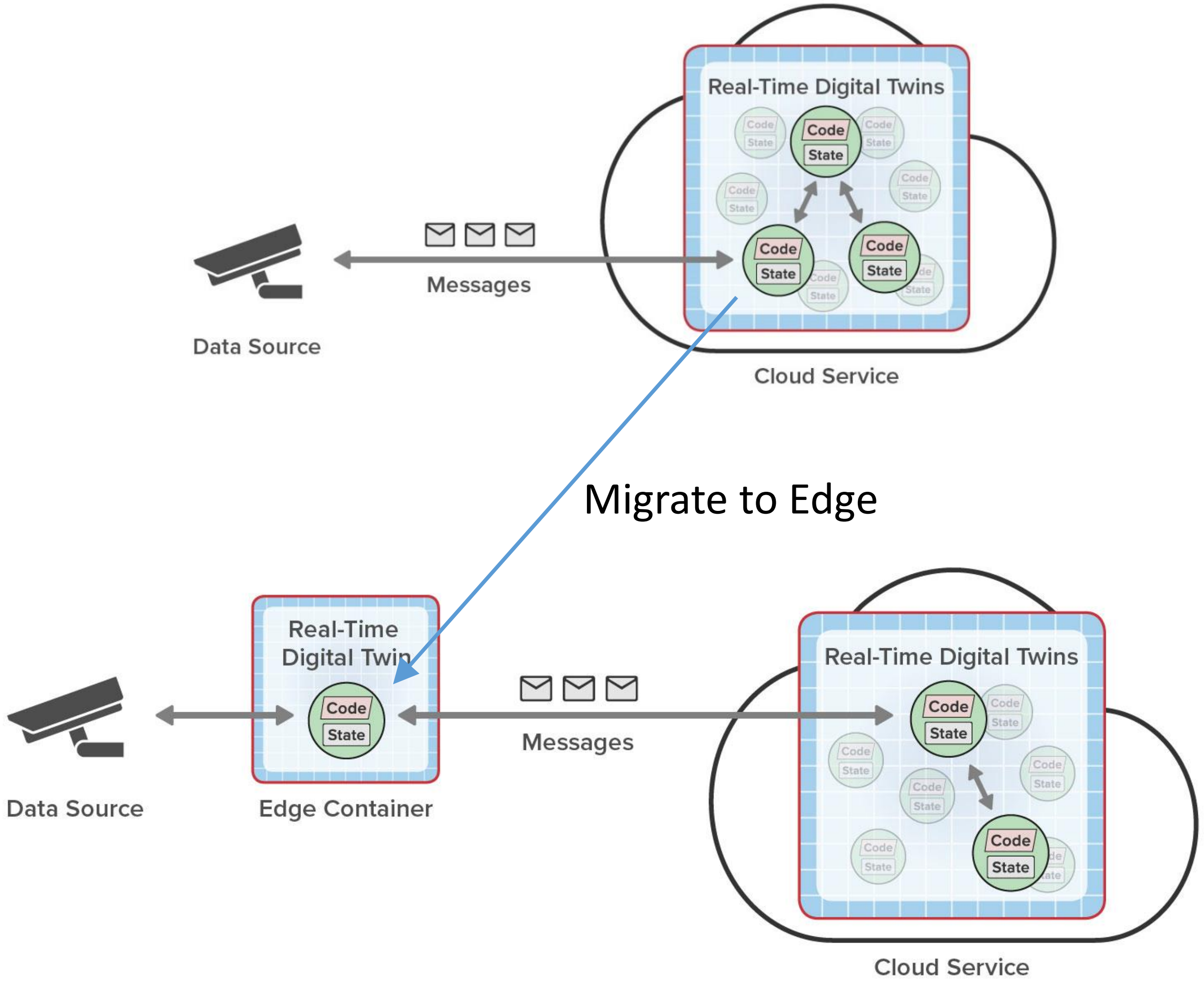
- Real-time digital twins can naturally be organized into hierarchies.
- As edge computing becomes more capable, low-level real-time digital twins can migrate from a cloud service to edge containers:
  - Avoids programming changes and enables a uniform development model.
  - Allows division of labor between edge (device specific) and cloud (strategic).
  - Reduces message traffic.



Key Takeaways

- Digital twins aren't just for PLM.
- They offer a powerful software architecture for real-time monitoring and predictive modeling of large systems.
- Numerous applications in diverse verticals can benefit:
    - Transportation
    - Logistics
    - Disaster Recovery
    - Many more
- In-memory computing provides a key enabling technology:
    - Fast responses
    - Transparent scaling
    - Aggregate analytics
    - Real-time visualization

ScaleOut
Digital Twins

- Solves important unmet challenges for real-time monitoring and predictive modeling.
- Addresses key application scenarios in security, logistics, healthcare, disaster recovery, and more.
- Individually tracks 1000s of data sources in real time.
- Simulates 100s to millions of entities.
- Integrates real-time, aggregate analytics and query.
- Pinpoints operational issues fast with an agile solution.
- Dramatically simplifies application development.
- Automatically scales and delivers high availability.
- **Enables users to maximize situational awareness and decision-making with minimum effort.**

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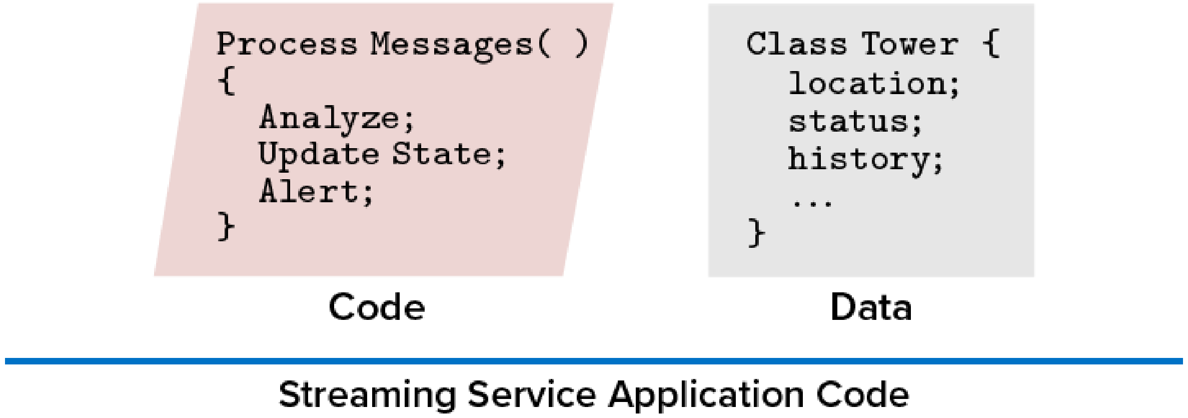
Example: Simulated Power Grid

Application code is dramatically simplified:

- Developer just implements one message processing method and state object for a single real-time digital twin.
  - Approximately 20 Java statements in this demonstration
- Platform automatically runs this code for all data sources.
  - Automatically correlates incoming messages by data source.
  - Automatically scales to handle large workloads.
- Developer avoids:
  - Selecting telemetry out of a single, combined event stream
  - Creating ad hoc storage for contextual data
  - Pushing the data into a data lake for offline analysis using Spark



Power Grid Demo Code

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- Definition of state object (Java):

```java
public class StatusTracker extends DigitalTwinBase {
    // State variables
    public String node_type;
    public String node_condition;
    public String region;
    public double longitude;
    public double latitude;
    // Derived state variables
    public int alert_level;
    public int minorIncidentCount;
    public int moderateIncidentCount;
    public int falseIncidentCount;
    public int severeIncidentCount;
    public int totalIncidents;
    public int totalResolvedIncidents;
    public boolean experiencingIncident;
    // Dynamic incident report list
    public List<IncidentReport> incidentList;}
```

Power Grid Demo Code

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- Sample message-processing code (Java):

```java
public ProcessingResult processMessages(ProcessingContext processingContext, StatusTracker digitalTwin,
                                        Iterable<StatusTrackerMessage> messages) throws Exception {
   // Iterate through the incoming messages:
   for(StatusTrackerMessage msg : messages) {
       // if the message indicates a moderate incident and this tracker has never had a severe
       // incident while the heuristic false incident ratio is greater than 50%, boost the alert level:
       if(msg.moderateIncident() &&
           digitalTwin.getSevereIncidentCount() == 0 &&
           digitalTwin.getModerateIncidentCount() > 0 &&
           ((double)(digitalTwin.getFalseIncidentCount()/
                     digitalTwin.getModerateIncidentCount()) >= 0.5)) {
               digitalTwin.setAlertLevel(Constants.MODERATE+3);
               digitalTwin.incrementModerateEventCount();
               digitalTwin.setStatusTrackerCondition(msg.getNodeCondition());
           }
       // ... [additional rules]
   }
   return ProcessingResult.UpdateDigitalTwin;}
```