DIM Lab

Real-Time Digital Twin

Two Examples

Why Digital Twins?

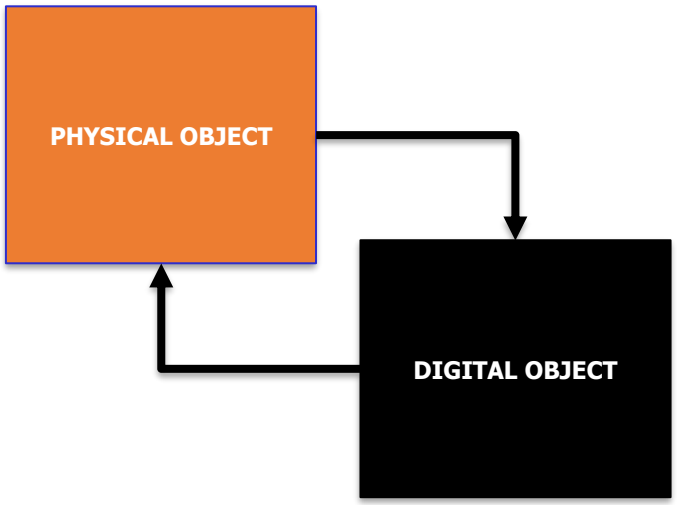
- Simulation is **just a simplification** of reality: conditions imposed by users do not consider too many variables and characteristics
- Industry 4.0 strives for **more complex simulation systems** that are able to simulate the whole reality and even influence it
- Coupling Industry 4.0 technologies enables such a solution in the form of the **Digital Twin**

Meaning of Real-Time Digital Twin

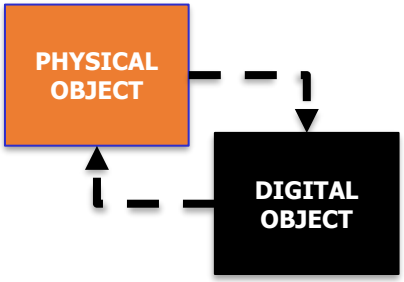
- Real-time digital twins leverage in-memory computing technology to turn the conventional model for streaming analytics on its head and enable each data source to be independently tracked and responded to in real time
- **A real-time digital twin is a software object that encapsulates dynamic state information for each data source combined with application-specific code for processing incoming messages from that data source**
- This state information gives the code the context it needs to assess the incoming telemetry and generate useful feedback within 1-3 milliseconds

Digital Twin

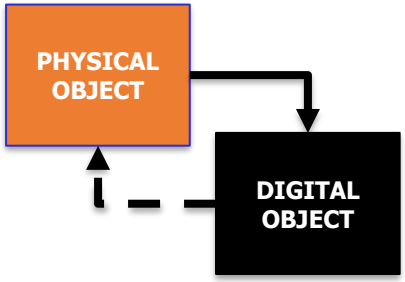
- The term Digital Twin has entered the regular vocabulary of all industry sectors, but the broad scope of the concept makes a **common definition difficult to provide**
- "*A set of virtual information constructs that fully describes a potential or actual physical manufactured product from the micro atomic level to the macro geometrical level. At its optimum, any information that could be obtained from inspecting a physically manufactured product can be obtained from its Digital Twin*" (Grieves, M. 2016)



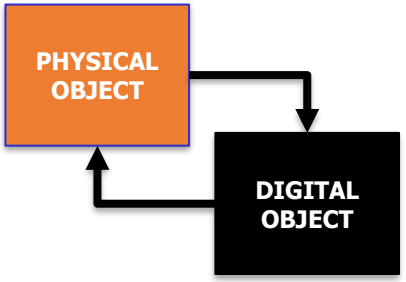
Maturity level of a Digital Twin



DIGITAL MODEL



DIGITAL SHADOW



DIGITAL TWIN

Meaning of Real-Time Digital Twin

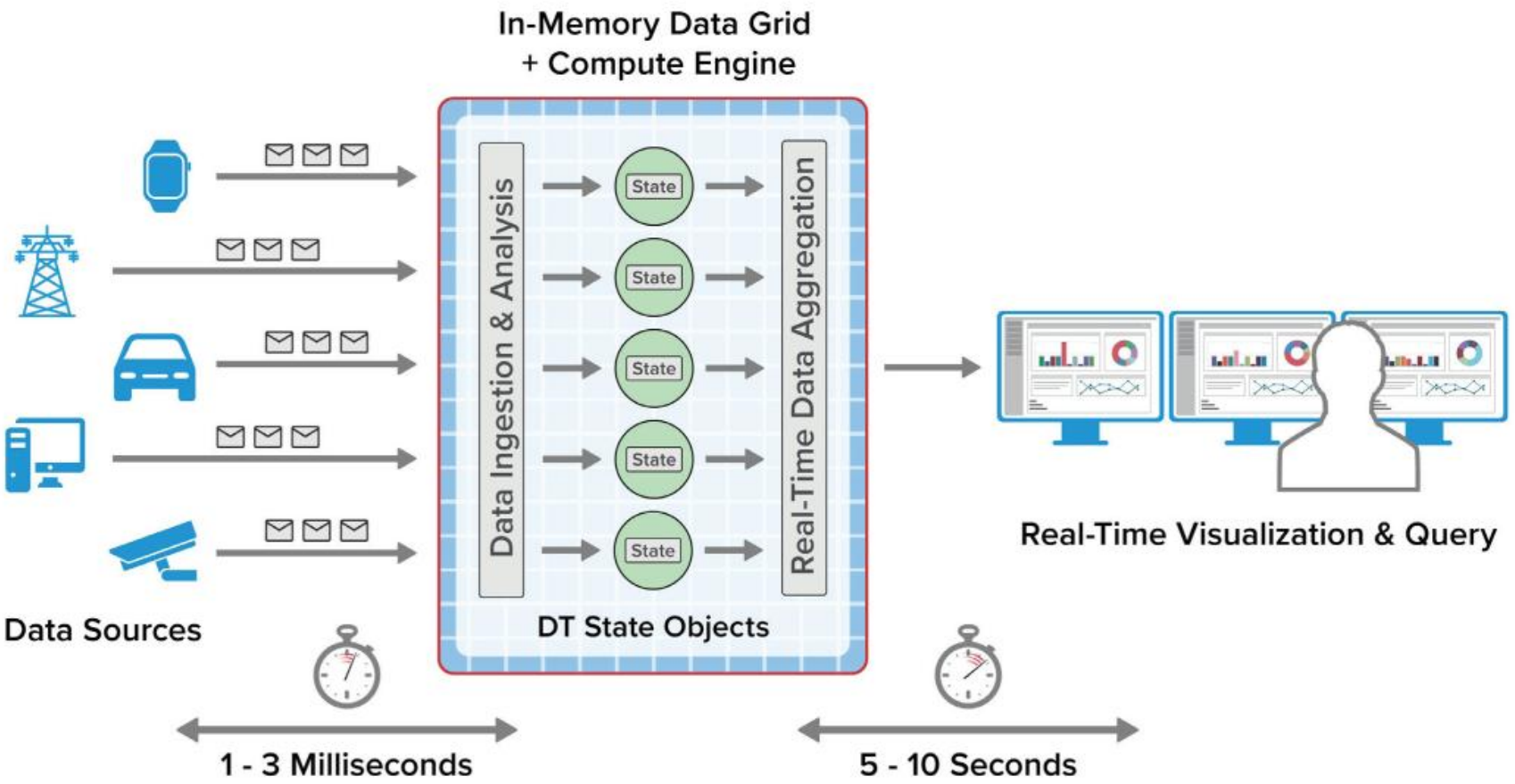


Figure 1: An in-memory computing platform hosting real-time digital twins

Source: Real-Time Digital Twins: the next generation in streaming analytics (ScaleOut Software)

Using State Information for Aggregate Analytics

- State information held within real-time digital twins provides a significant repository of data that can be analyzed in aggregate to immediately spot important trends
- With in-memory computing, aggregate analysis can be performed continuously every few seconds instead of waiting for offline analytics in a data lake
- State information maintained for each data source and updated as telemetry flows in can be extracted from all real-time digital twins and aggregated to highlight emerging patterns or issues that may need attention
- This provides a **powerful tool for maximizing overall situational awareness**

Trucking Fleet Management

- With traditional streaming analytics, personnel can detect changes in these parameters, but they can't assess their significance and take effective, individualized action for each truck
- But:
  - Is a truck stopped because it's at a rest stop or because it has stalled?
  - Is an out-of-spec engine parameter expected because the engine is scheduled for service, or does it indicate that a new issue is emerging?
  - Has the driver been on the road too long?
  - Does the driver appear to be lost or entering a potentially hazardous area?

- The use of real-time digital twins provides the context needed for the application to answer these questions as it analyzes incoming messages from each truck
- For example, it can keep track of the truck's route, schedule, cargo, mechanical and service history, and information about the driver.

Trucking Fleet Management

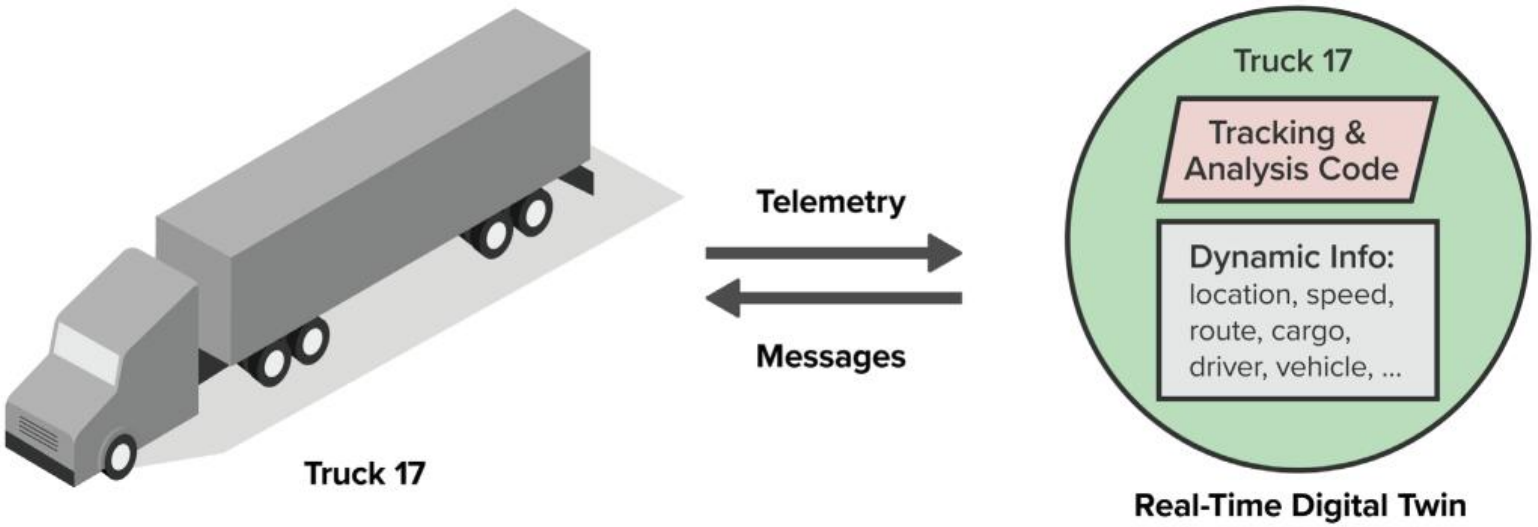


Figure 4: Example of a truck sending telemetry to its real-time digital twin

Source: Real-Time Digital Twins: the next generation in streaming analytics (ScaleOut Software)

Trucking Fleet Management

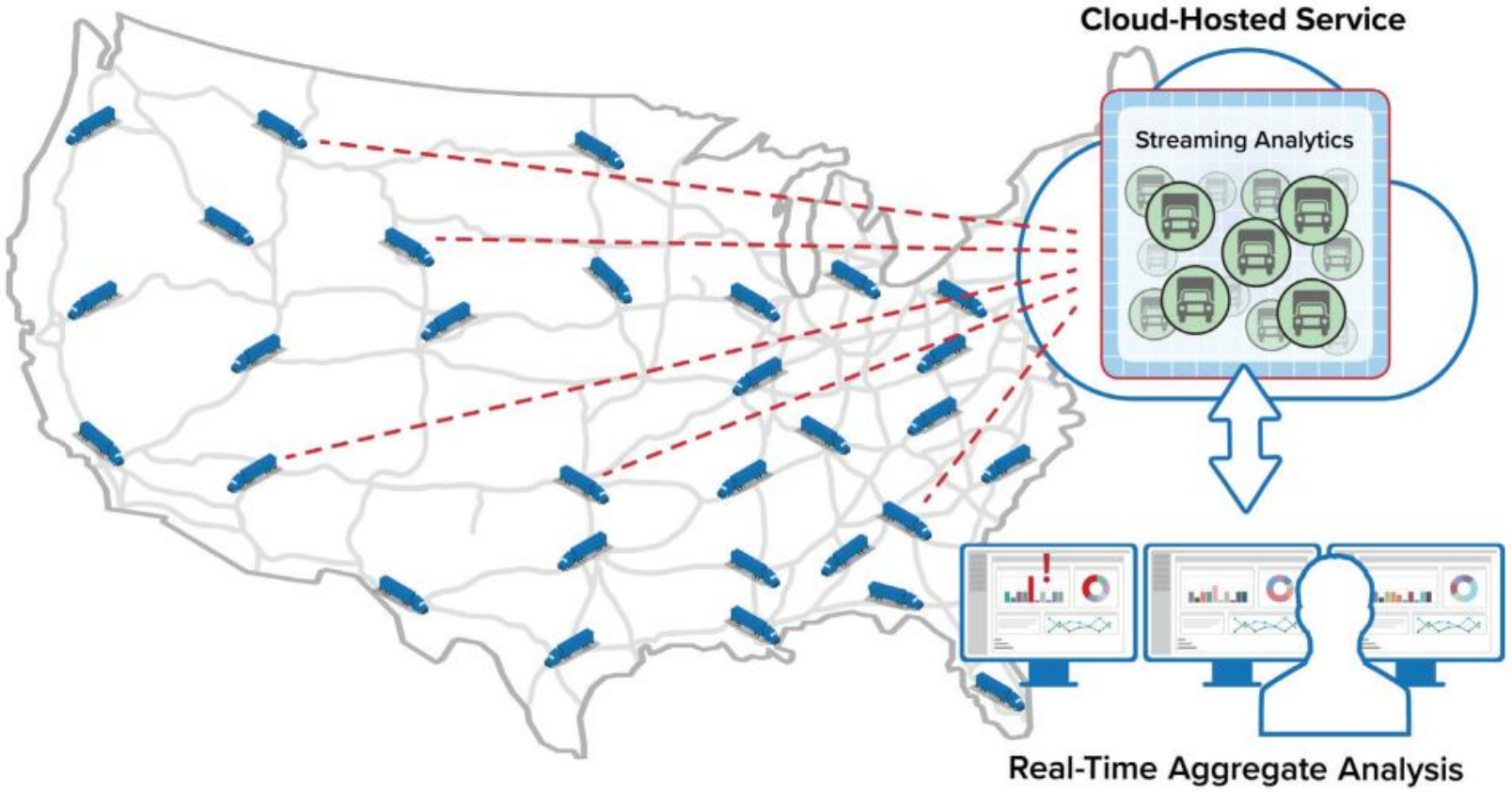


Figure 5: Example of a cloud service using real-time digital twins to manage a fleet of trucks

Source: Real-Time Digital Twins: the next generation in streaming analytics (ScaleOut Software)

COVIS-19 Crisis

- Consider an emergency monitoring system during the COVID-19 crisis that tracks the need for supplies across the nation's hospitals and attempts to quickly respond when a critical shortage emerges
- All hospitals send messages every few minutes to this system, which runs in a central command center
- These messages provide updates on various types and amounts of shortages (for example, of PPE, ventilators, and medicines) that the hospitals need to quickly rectify
- Using state information, a real-time digital twin for each hospital can both track and evaluate these shortages as they evolve
- It can look at **key indicators**, such as the relative importance of each supply type and the rate at which the shortages are increasing, to create a dynamic measure of urgency that the hospital receive attention from the command center
- All of this data can be continuously updated within the real-time digital twin as messages arrive to give personnel the latest status

COVID-19 Crisis

- Aggregate analysis can then compare this data across all hospitals by region to identify which regions have the greatest immediate need and track how fast and where overall needs are evolving
- Personnel can query state information within the real-time digital twins to quickly determine which specific hospitals should receive supplies and what specific supplies should be immediately delivered to them
- Using real-time digital twins, all of this can be accomplished in seconds or minutes

COVID-19 Crisis

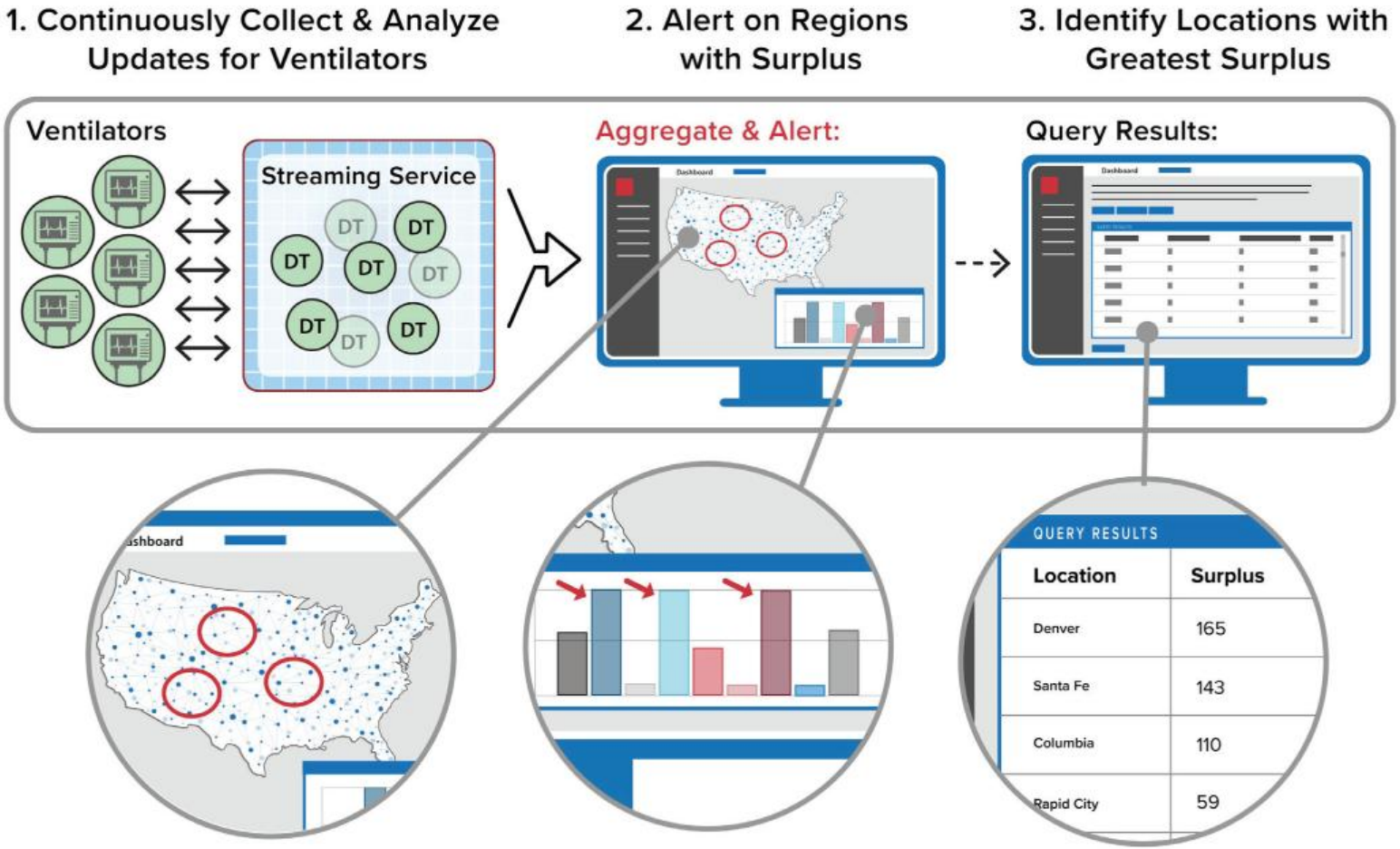


Figure 6: Aggregate analysis of state information in real-time

Source: Real-Time Digital Twins: the next generation in streaming analytics (ScaleOut Software)

- Each twin comprises a state object holding dynamic information about the data source and an application-defined, message-processing method and/or machine learning algorithm that analyzes incoming events and generates outgoing messages and alerts