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# Deeper dive to digital twin concept Future and features

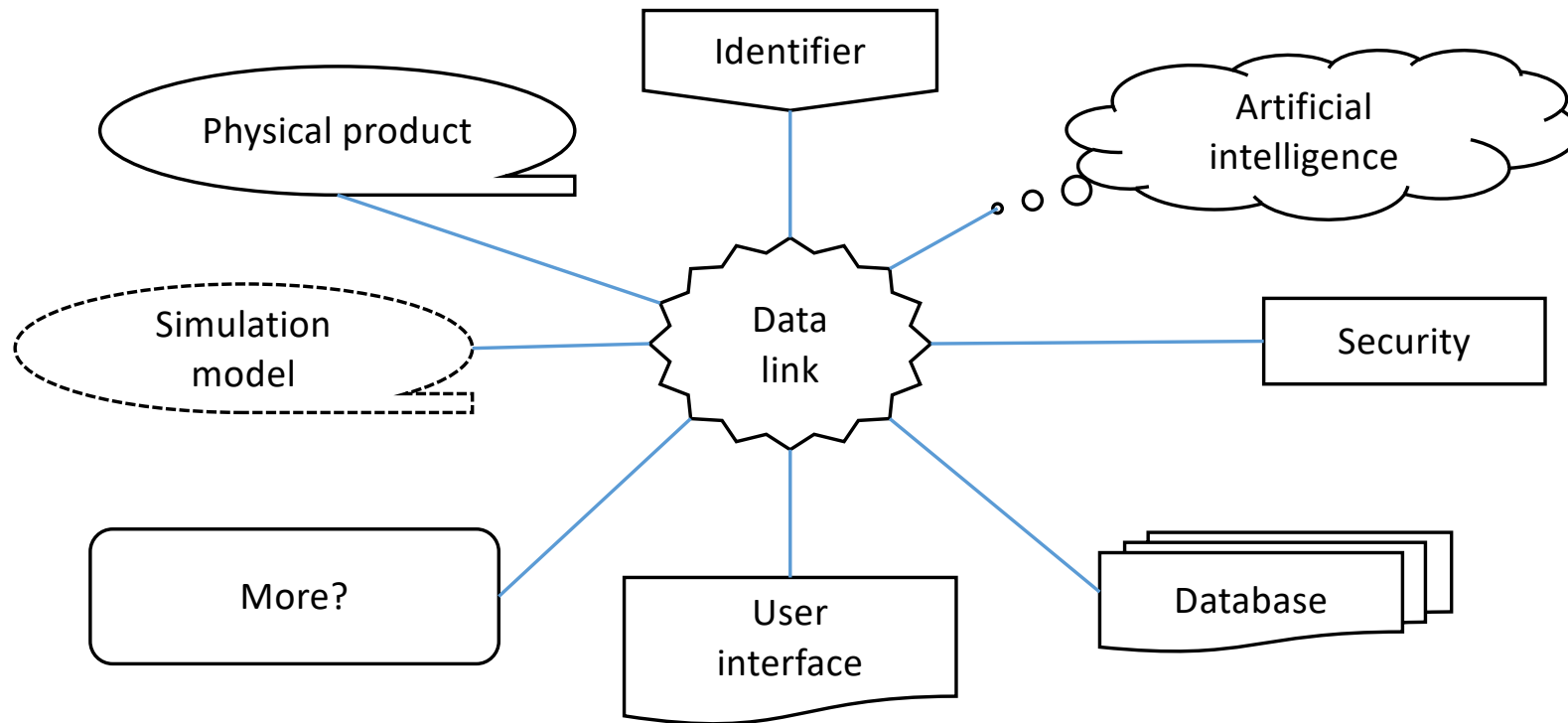
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Working title of doctoral thesis:  
Digital twin for industrial products

# What is a digital twin?



# Simulation model

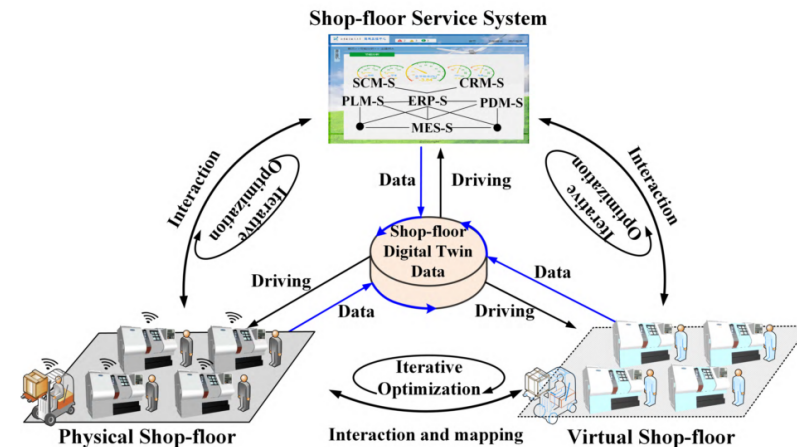
How to analyze behavior of the physical twin?

Countless different alternatives: CAE, 3D or process

Perhaps the most common example of Digital Twin!

Specific use cases:

- Digital Twin Shop-floor
- Virtual prototyping



Tao, F., & Zhang, M. (2017). Digital Twin Shop-floor: A New Shop-floor Paradigm towards Smart Manufacturing. *IEEE Access*. <https://doi.org/10.1109/ACCESS.2017.2756069>



Michael, S., & Juergen, R. (2016). From Simulation to Experimentable Digital Twins: Simulation-based development and operation of complex technical systems. In *2016 IEEE International Symposium on Systems Engineering (ISSE)*. <https://doi.org/10.1109/SysEng.2016.7753162>

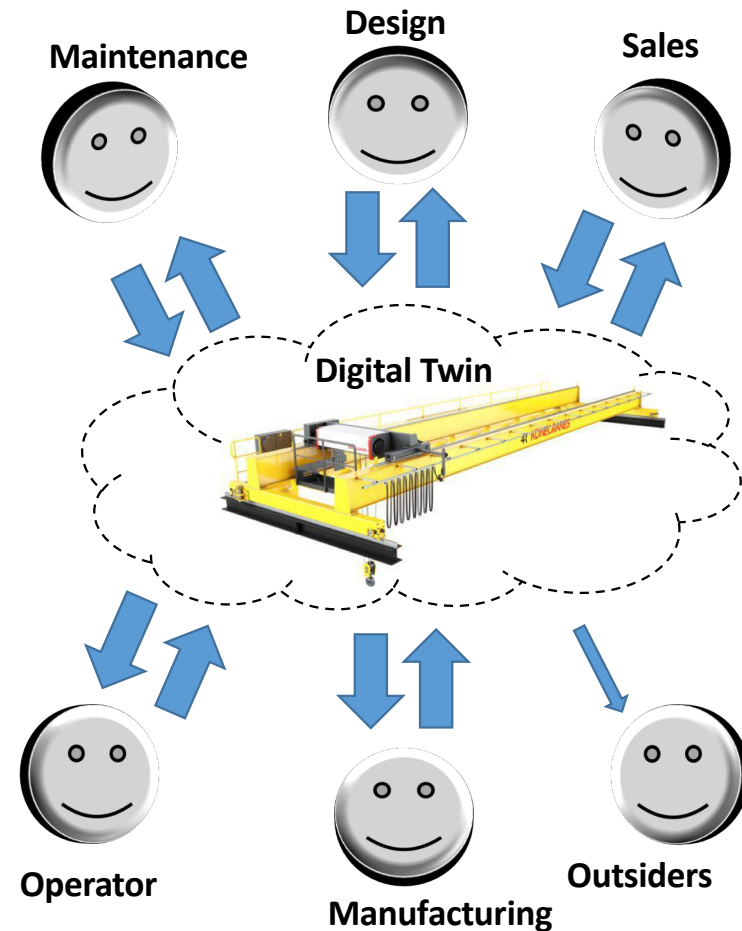
# User interface

What does the digital twin look like?

- Could be just a web site
- Different views and permissions for different users
- 3D model with AR would be nice!



<https://blogs.windows.com/devices/2017/09/20/ford-brings-microsoft-hololens-to-design-studio-drives-speed-creativity-and-collaboration/>



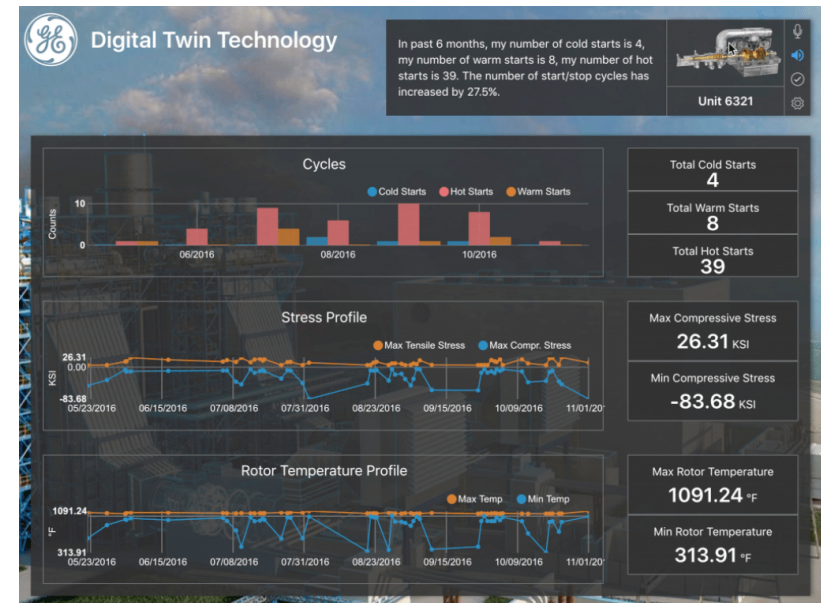
# Database

Where to store digital twin data?

In many cases, just showing the data may provide enough value.

There can be also multiple databases.

Possible contents include: Static 3D model, Measurement data (with error limits) Metadata/environment data, Location, Historical data (PLM aspect)



<https://www.applause.com/blog/digital-twins-iot-faq/>

# Identifier

How to access the digital twin?

- Globally unique address
- Existing examples include MAC, IP address, URL, DOI
- Technologies to access the identifier include RFID, QR code
- Can be used to access the Digital Twin
- Should be available at the "physical twin"



# Artificial intelligence

Makes DT an active or even autonomous object.

- For reference: compare the potential of a **regular car** to an **autonomous car**.
- AI enhanced DT actively takes care of the physical product.

Assistant for a machine

Use case examples:

- Analyse the condition of physical twin
- Reschedule maintenance if needed
- Trigger alarm or even stop the machine

# Security

Safe and consistent operation are minimum requirements for adopting any new system, and DTs are no exception.

**Security by design** must be implemented throughout any DT

Furthermore, specific security features of DT include:

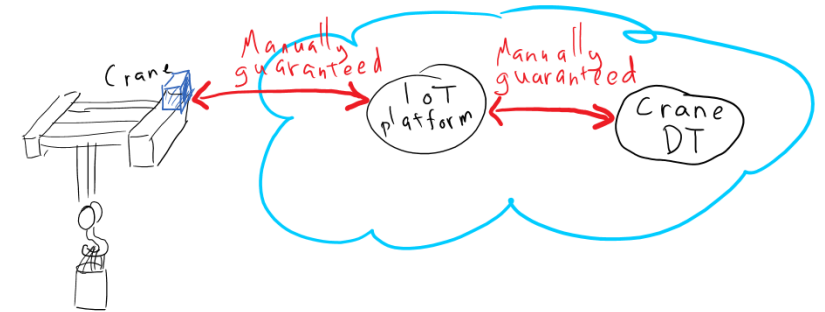
- User access management
- Update management service for the physical product
- AI based scanning of network environment



# Computation

Computation can take place in various locations:

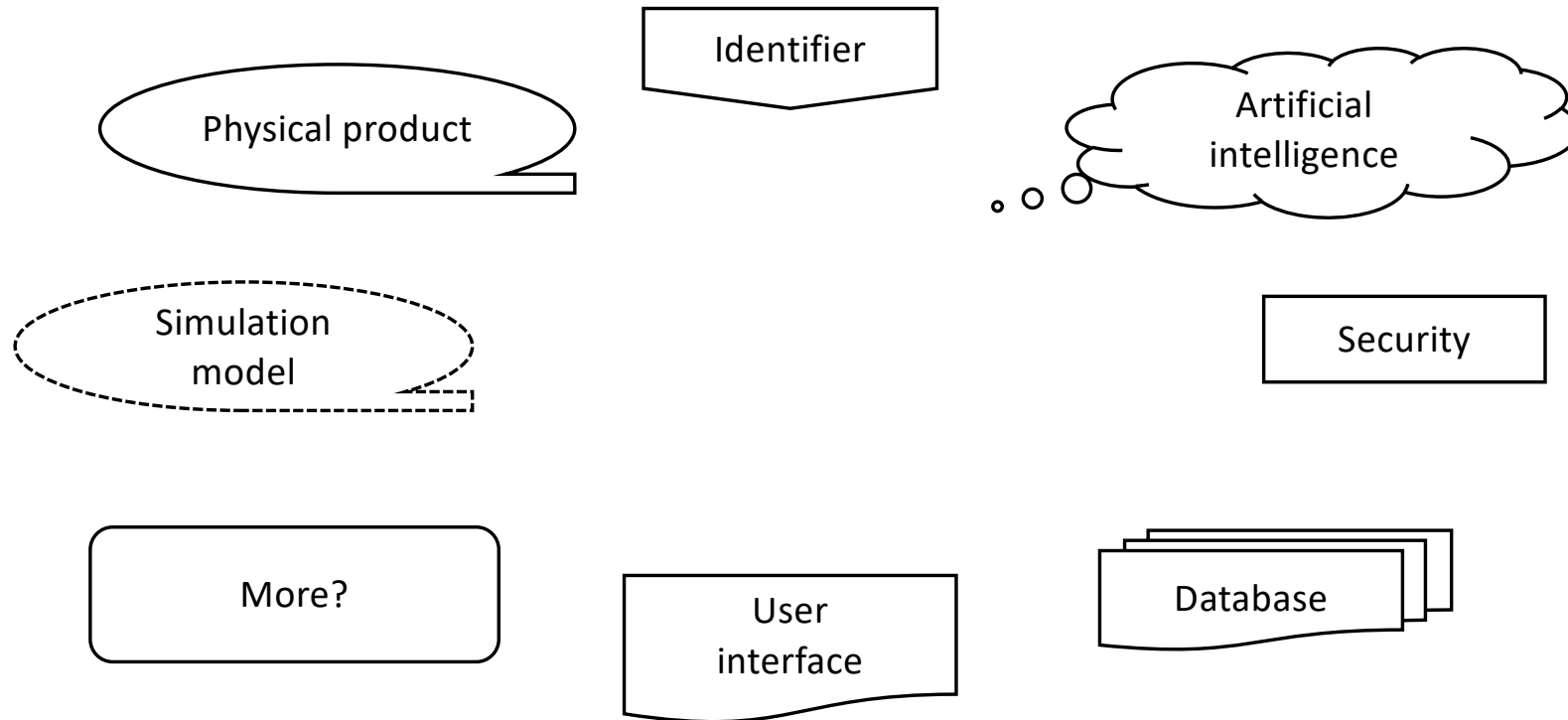
- locally at the device
- at the edge in a gateway device
- in the cloud at some server hardware



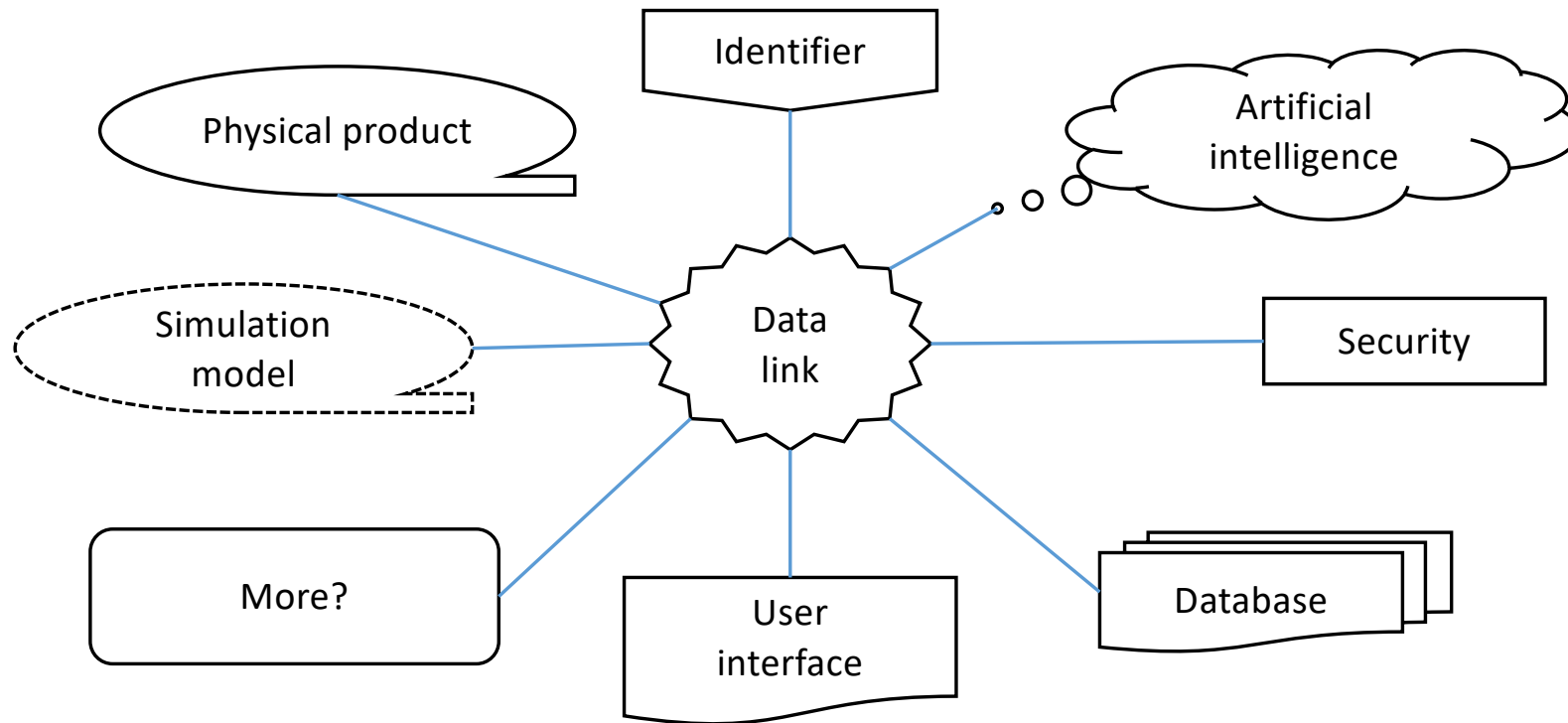
Digital twin should orchestrate where the computation takes place depending on the time scale and computational intensity.

- Remote computing enables use of low-cost IoT devices, while local computation lowers the need for communication bandwidth

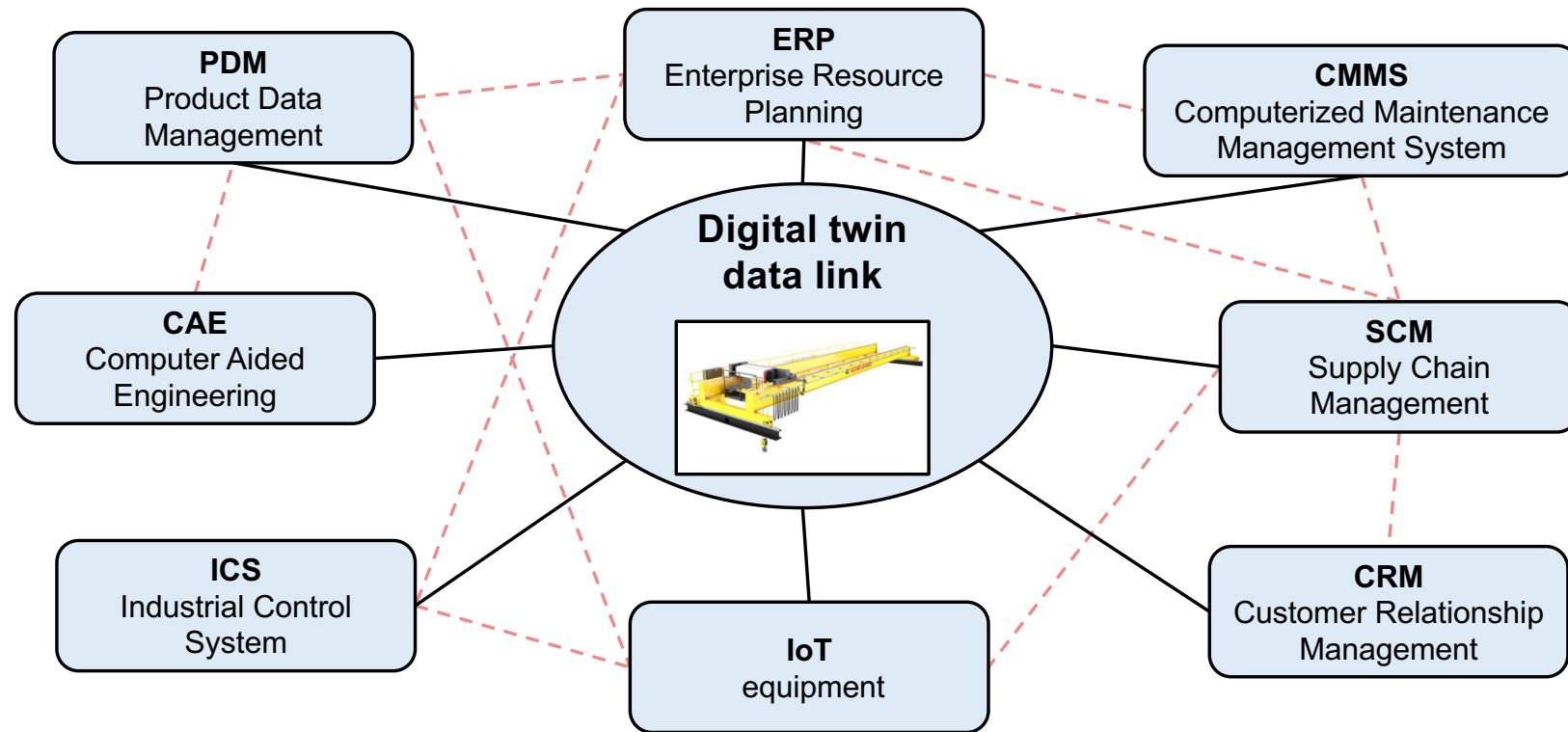
# How to combine the blocks?



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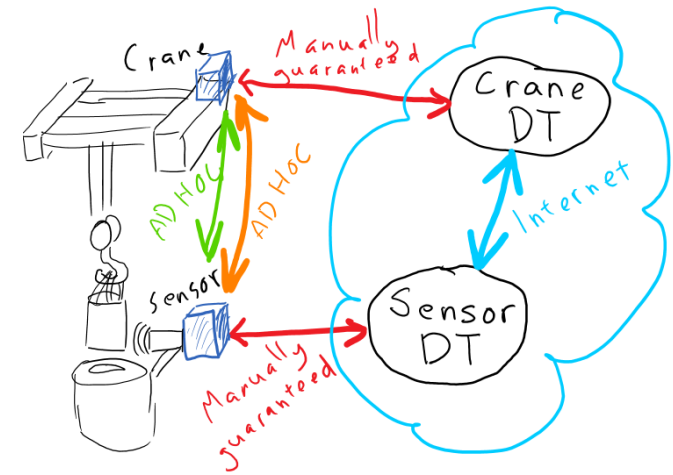
# How to use DT in enterprise context?



# Data link

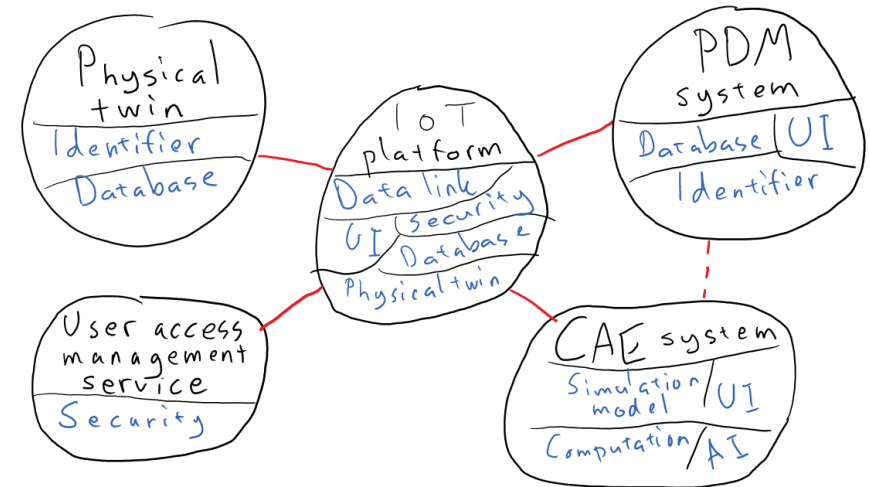
Probably the most difficult issue because of the multiple requirements

- APIs for I(I)oT/M2M and connectivity
- Connection to physical twin
- Links to external databases

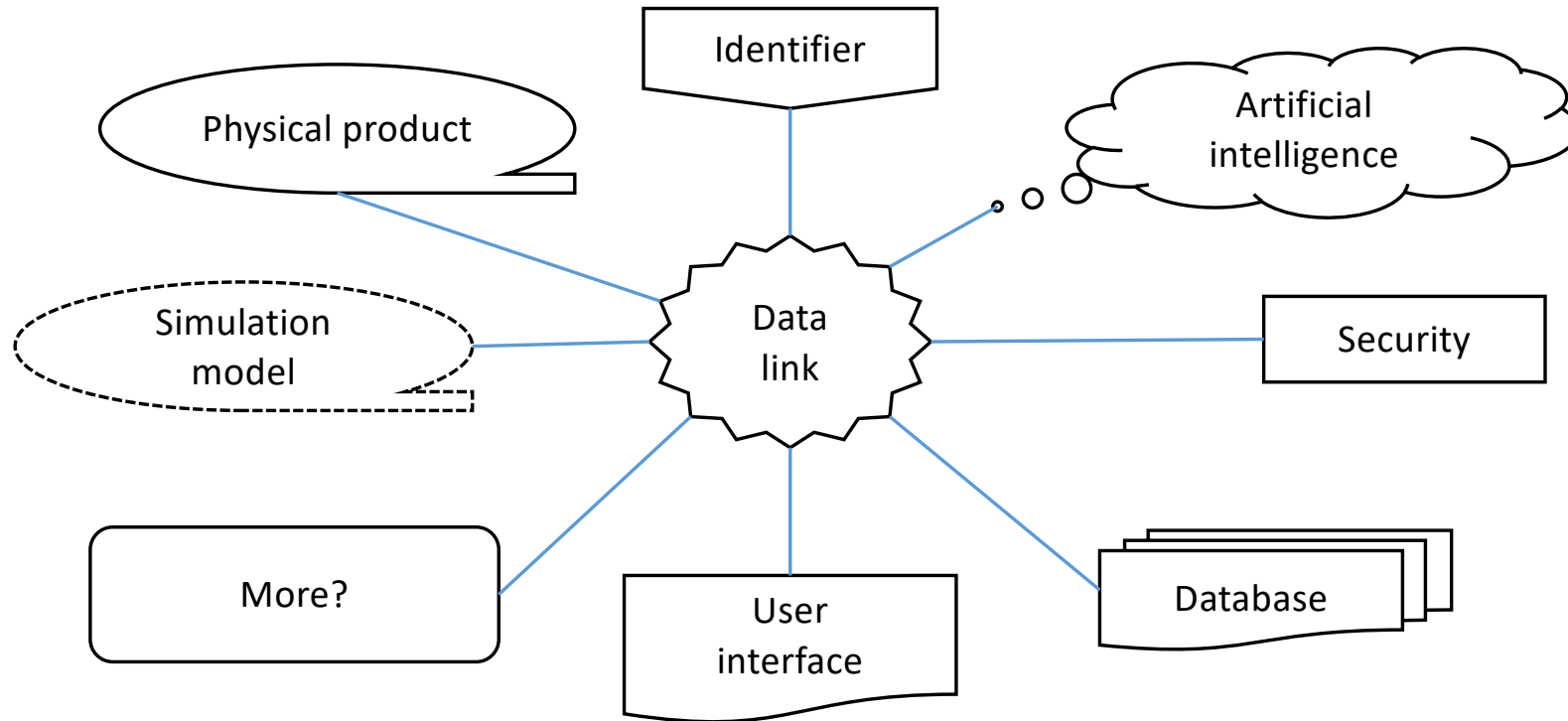


Basic idea proposed in:

Hribernik, K. A. *et al.* (2006) 'The product avatar as a product-instance-centric information management concept', *International Journal of Product Lifecycle Management*, 1(4), p. 367. doi: 10.1504/IJPLM.2006.011055.



# Conclusion?





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# Questions?