



Digital Twins and Social Networks

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Asset Management Group

Objective

- Develop tools and methodologies to realise value obtained from industrial asset systems.

Approach

- Innovative methods for optimising asset management decisions
- Effective exploitation of asset data and information

Industry Partners

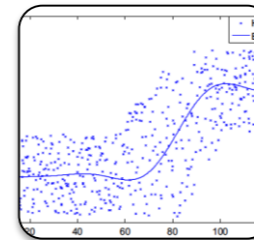


Areas of Research



Asset Management Strategy

- Whole-life Value analysis
- Criticality analysis
- Asset Information Management



Data-driven decision-making

- Maintenance and inspection planning
- Diagnosis and prognosis of asset failures
- Predictive maintenance



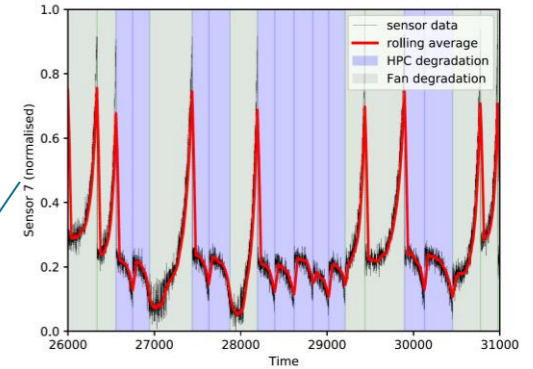
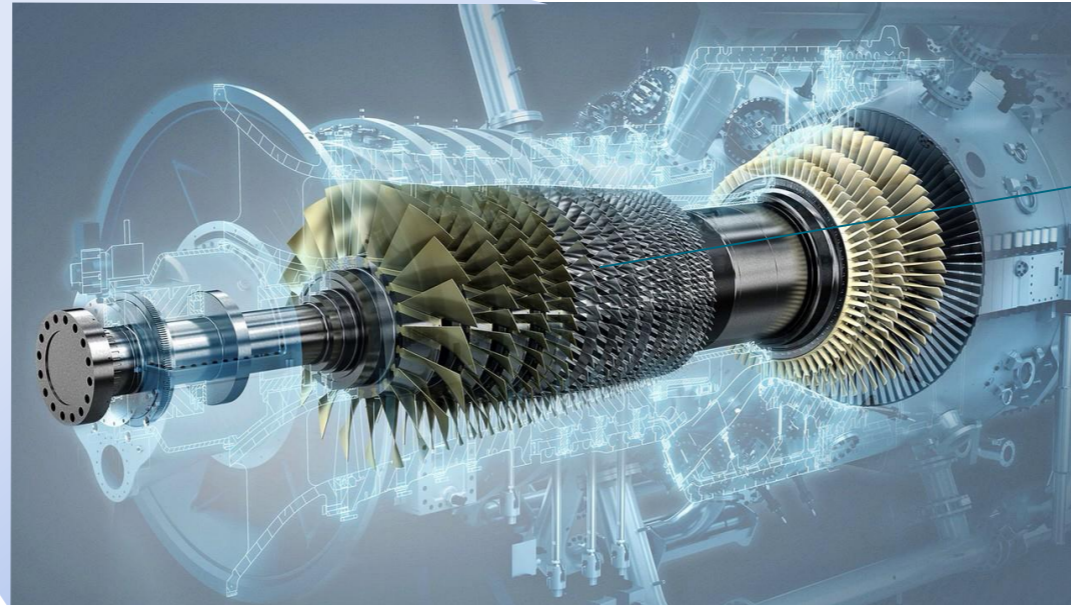
Exploiting emerging technologies

- Digital Twins
- Cyber-Physical Systems
- Augmented Reality

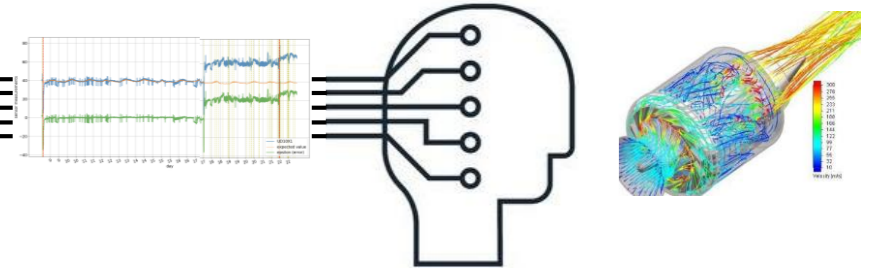
Digital Twins exploits the power of data to realise value from assets



DIGITAL TWIN

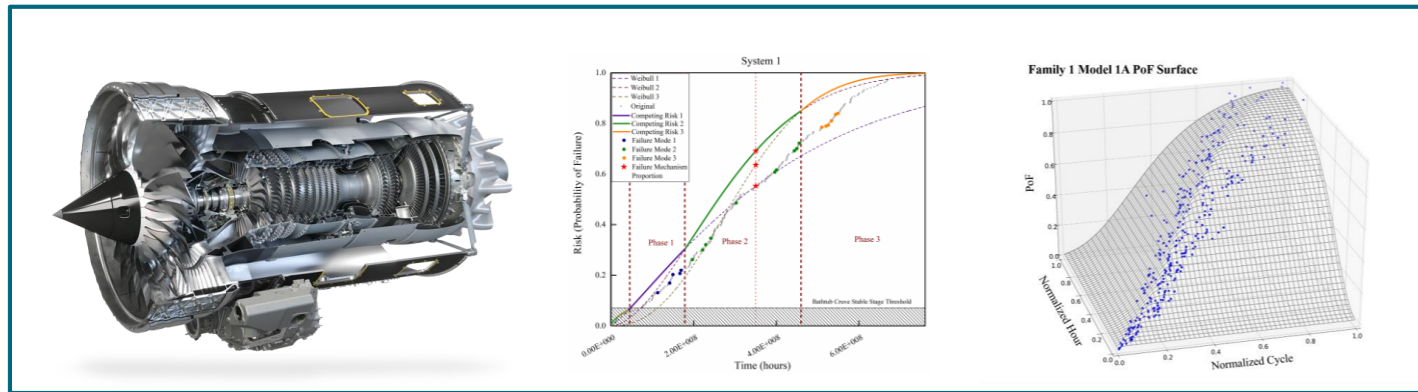


STATE: ON
POWER: 999 MW
HOURS: 934



ALERT: ABNORMAL OPERATION!
ALERT: SHUTDOWN IN 7±2 MINS
ACTION: REDUCE LOAD BY 25%

Data-driven reliability engineering can inform optimal asset usage and maintenance



Airline Operator

- British Airway
- Emirates
- Cathy Pacific
- Turkish Airways
- Lufthansa

Engine Model

- Trent 700 300kN Thrust
- Trent 700 320kN Thrust
- Trent 900 280kN Thrust
- Trent 900 360kN Thrust
- Trent 1000 320kN Thrust

Product Label

- 2152
- 1047
- 1534
- 2443
- 1780

System Level

- Engine
- Sub-system
- Component

Sub-System Module

- Fan Case
- High Pressure Compressor
- Low Pressure Compressor
- High Pressure Turbine
- Low Pressure Turbine

Component

- High pressure compressor blade
- High pressure turbine blade
- Shaft
- Oil Pump
- Fan Disk

Recent operation history

- A-B
- B-C
- C-D
- D-E
- E-F
- F-G
- G-H
- H-I
- I-J
- J-K
- K-L

Input below engine next service route

- New York - Sao Paulo 9hr45min
- Sao Paulo - Lisbon 10hr05min
- Lisbon - New Delhi 14hr20min
- New Delhi - Hong Kong 5hr40min
- Hong Kong - Singapore 3hr30min
- Singapore - New York 18hr50min

Reliability Graphs

Search and Select Fault Found

Airline Operator

- British Airway
- Emirates
- Cathy Pacific
- Turkish Airways
- Lufthansa

Engine Model

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Product Label (Multiple)

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System Level

- Engine
- Sub-system
- Component

Module (Multiple)

- Fan Case
- High Pressure Compressor
- Low Pressure Compressor
- High Pressure Turbine
- Low Pressure Turbine

Component (Multiple)

- High pressure compressor blade
- High pressure turbine blade
- Shaft
- Oil Pump
- Fan Disk

Minimum repair cost

- HPT Blade
- Fan Disk
- Shaft
- Ball Bearing

System Input

Remaining Value (Engine Level)

- Individual Engine

Remaining Value (Module Level)

- Fan
- HPC
- IPC
- LPC
- CBT

Remaining Value (Component Level)

- HPT Blade
- HPC Blade
- IPC Blade
- Gear
- Ball Bearing

More Input

Input Overhaul Activity Cost

Restoration Rate

- HPT Blade
- Fan Disk
- Shaft
- Ball Bearing

By Clicking Overhaul Indication

Perform Minimal Repair

Perform Imperfect Maintenance

Move overhaul (Click here if indicates overhaul)

List of Opportunity Maintenance Module

- Fan
- HPC
- IPC
- LPC
- CBT

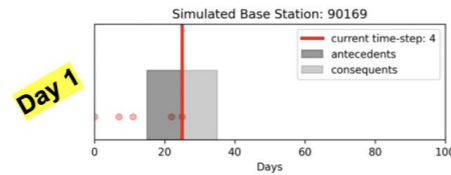
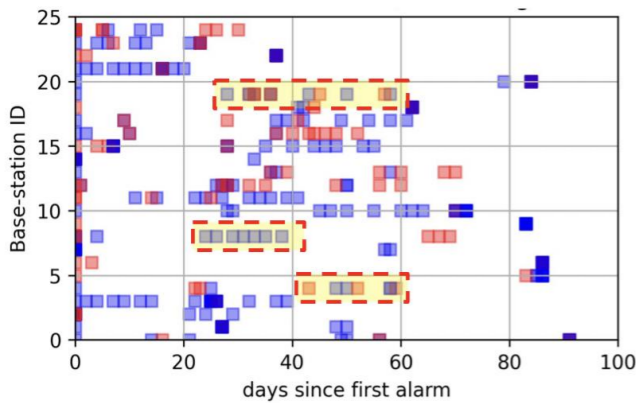
List of Opportunity Maintenance Component

- HPT Blade
- HPC Blade
- IPC Blade
- Gear
- Ball Bearing

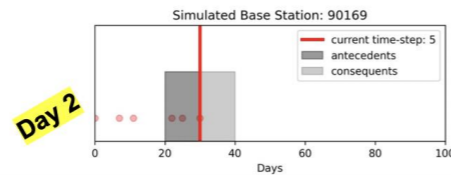
Asset Intelligence is improving service assurance of the telecoms infrastructure



Alarm groups in the base stations (major alarms and minor alarms)

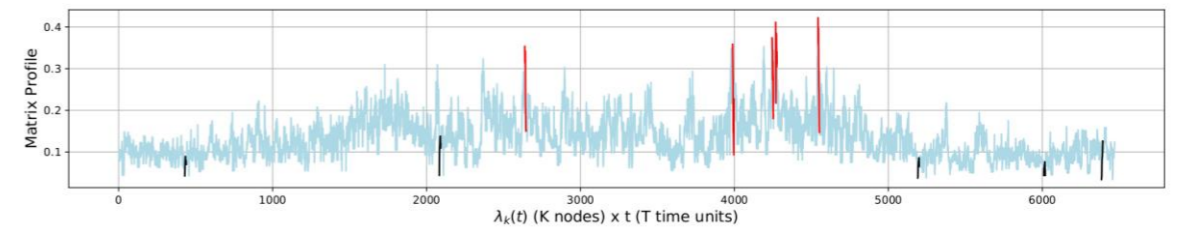
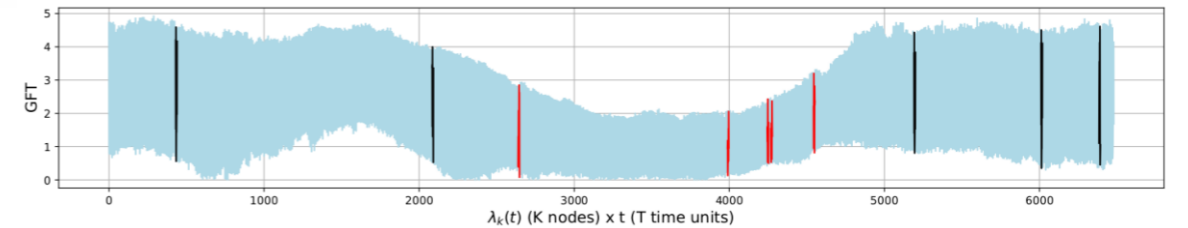
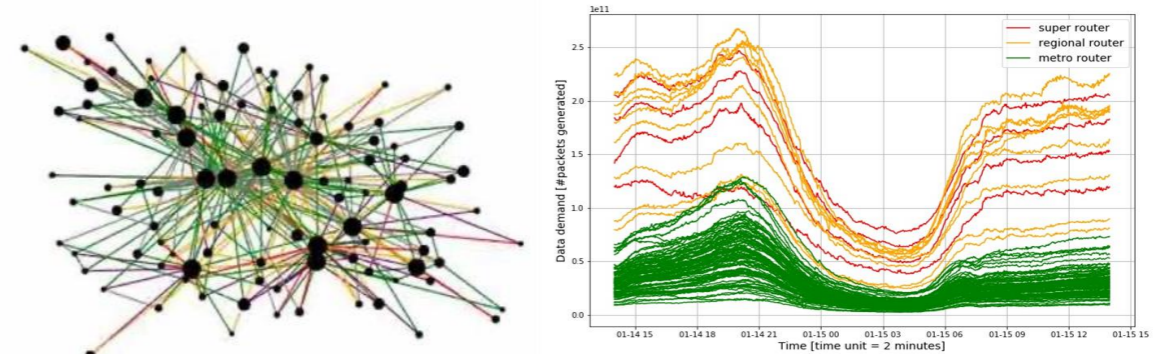


Antecedents	Consequents	Urgency
Board in Wrong Slot	Subrack Type and Configuration Mismatch	4.4
RAT Conflict between separate-MPT Boards	Board Type and Configuration Mismatch	3.6
	Automatic Version Rollback	3.3



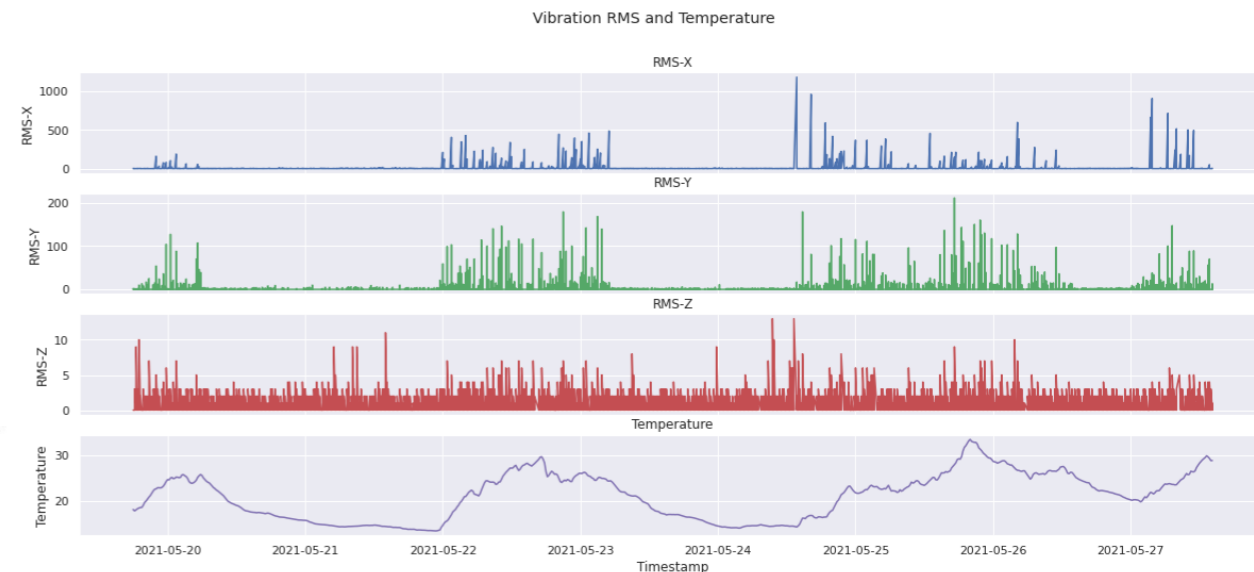
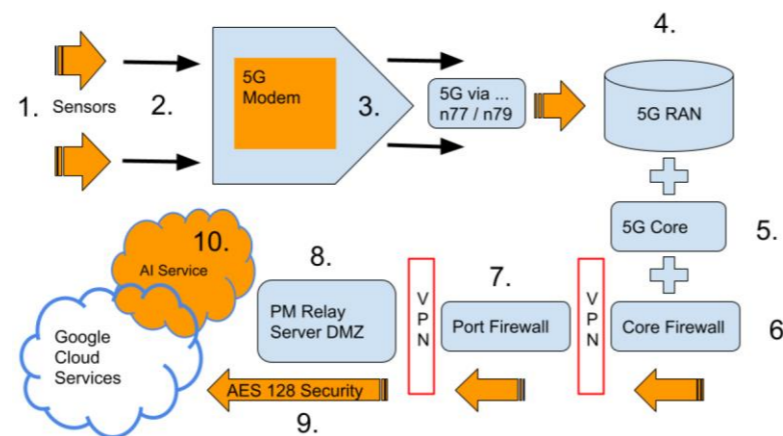
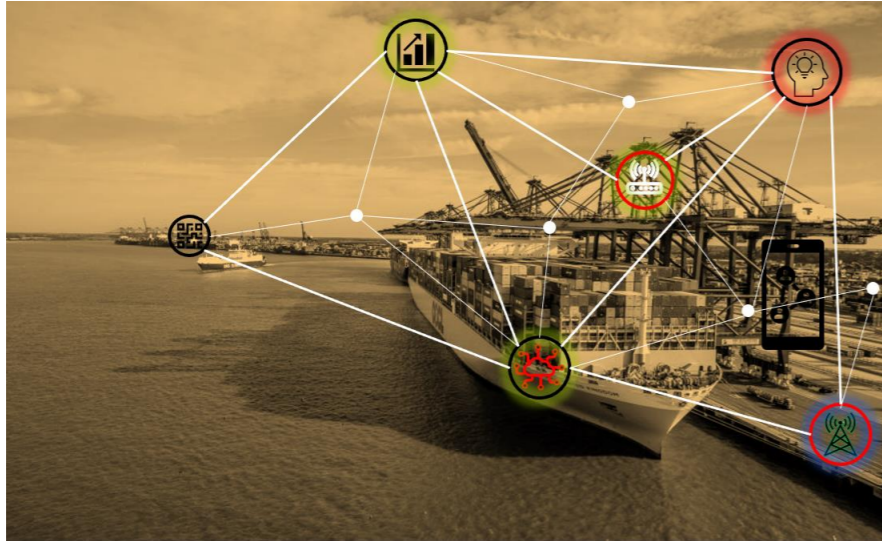
Antecedents	Consequents	Urgency
Board in Wrong Slot	Subrack Type and Configuration Mismatch	3.7
RAT Conflict between separate-MPT Boards	Automatic Version Rollback	3.1
Board Type and Configuration Mismatch	BBU Board Maintenance Link Failure	3.1

Predicting equipment failures



Network performance diagnostics

5G and IoT-enabled digital twins can transform productivity of logistics operations



We can stretch the idea of asset intelligence further...



This is the revised system PM plan!



I had an alternator failure now.



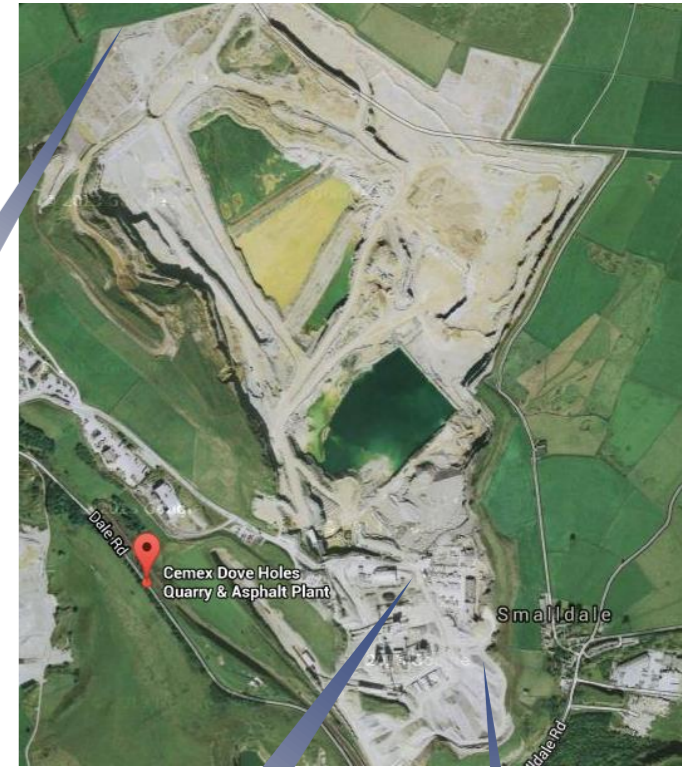
I am working as hard as you are. Hmm...I am likely to fail soon too!



Okay. Let me slow down a bit to help you out!



Unusual vibrations!
Suspected bearing failure in 3 days!



What do we need to make this happen?



See



Learn

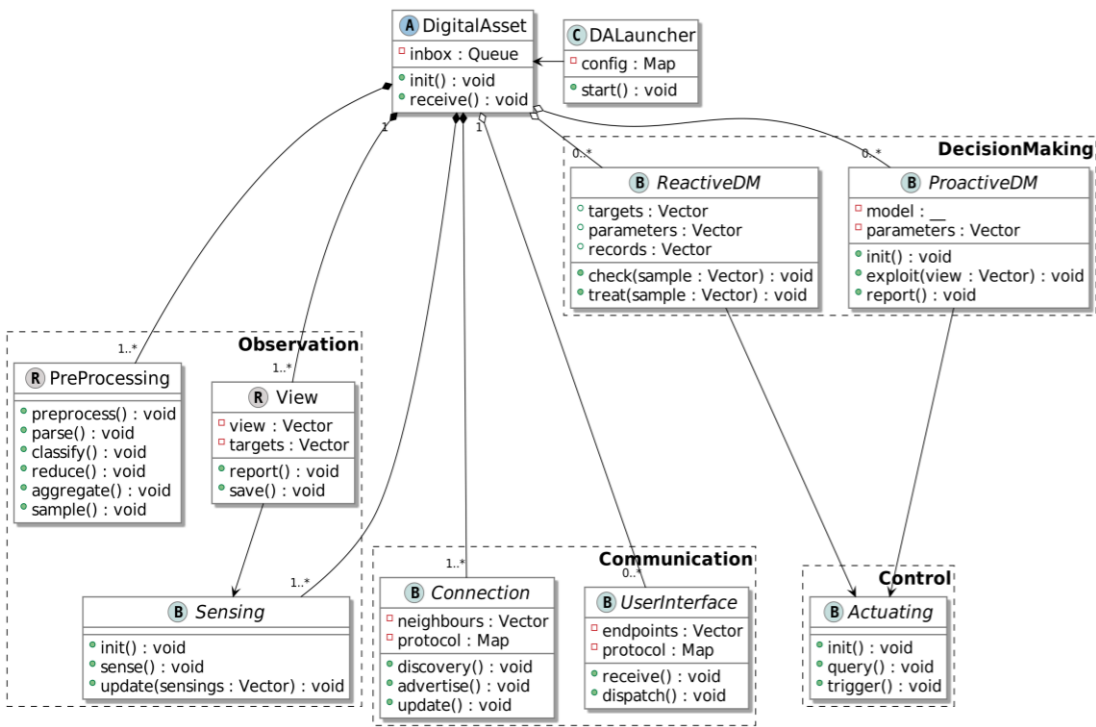


Think

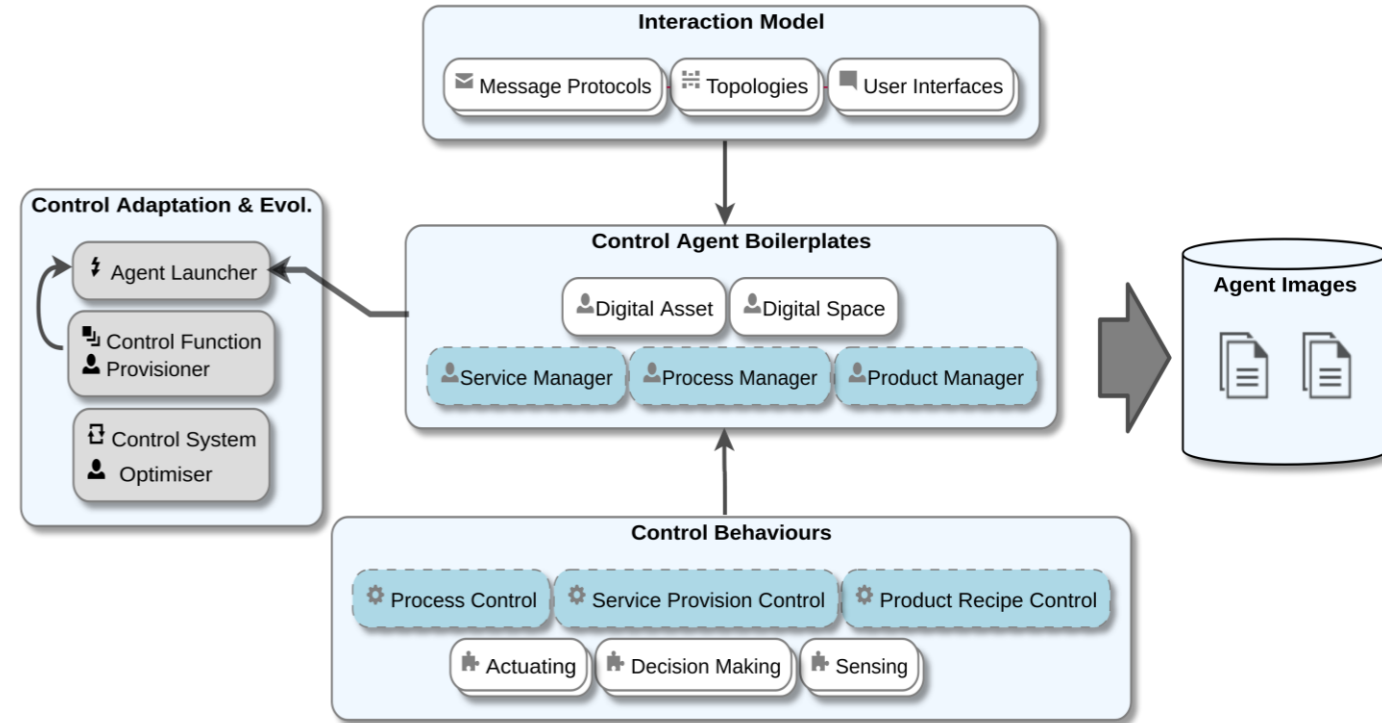


Act

'Agents' form the core enabler of social digital twins

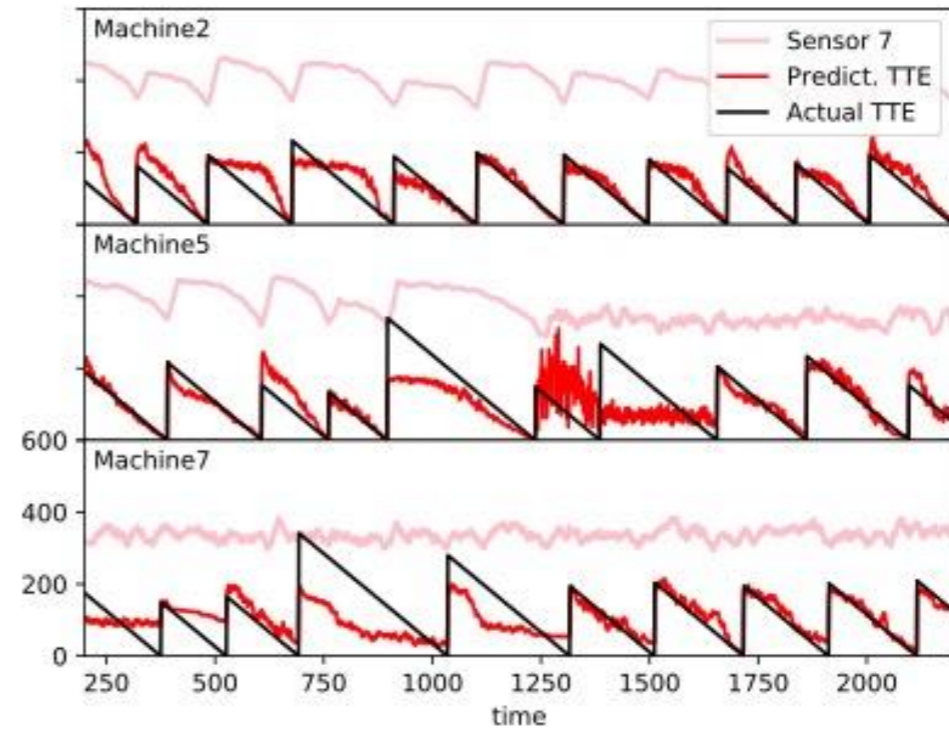
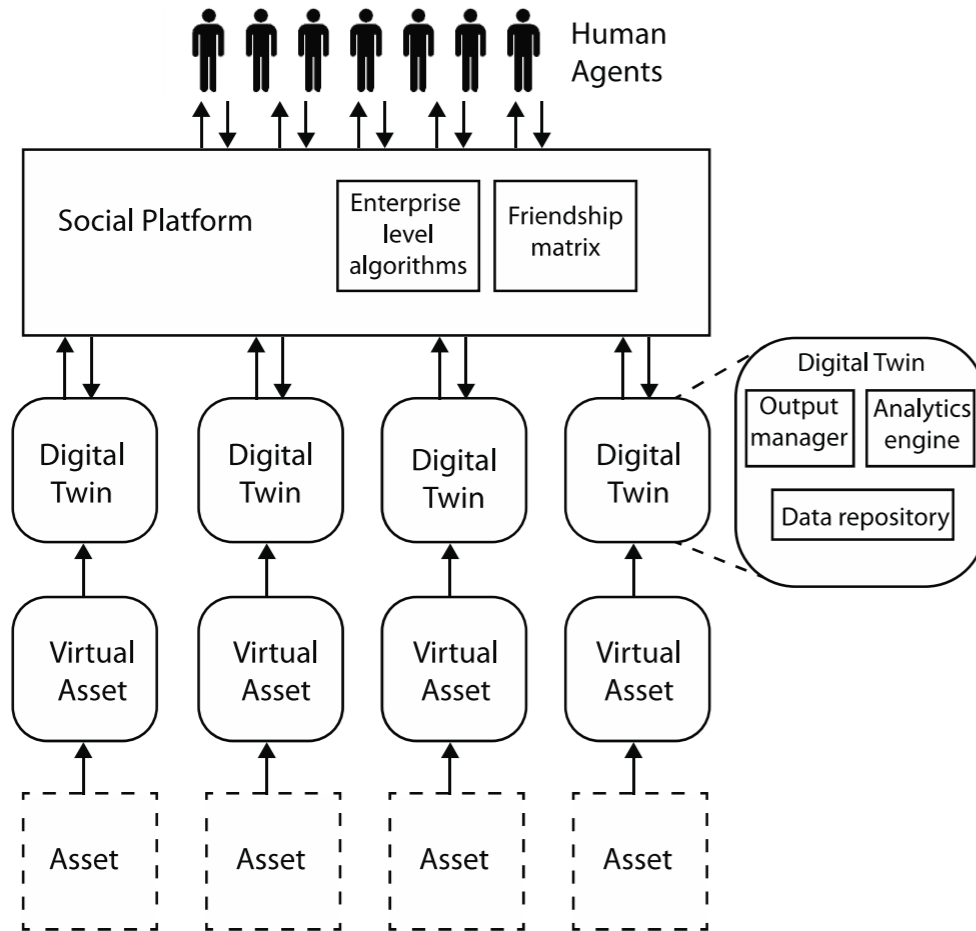


Internal architecture of 'containerised' agents

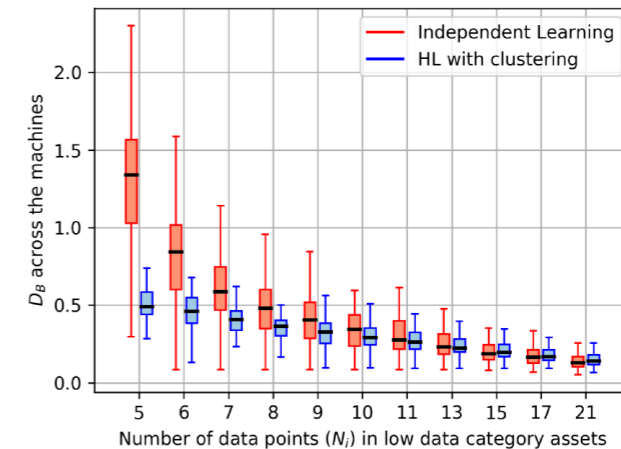
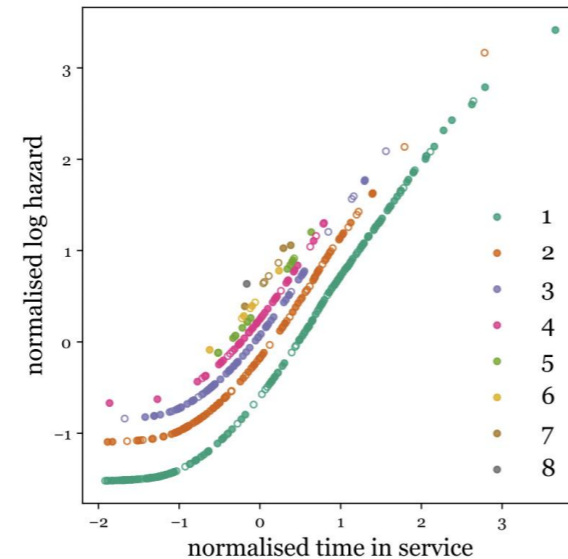
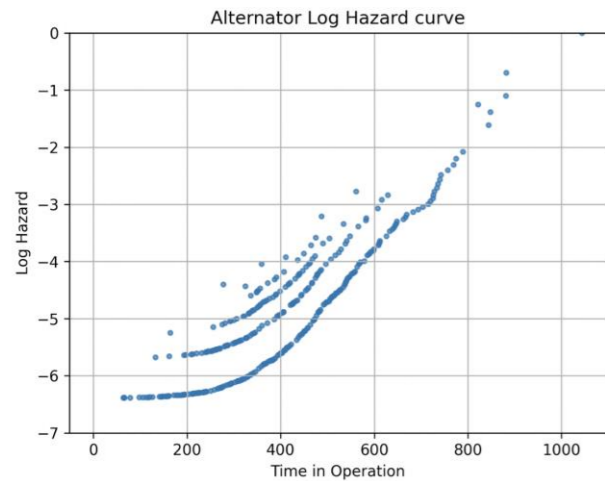
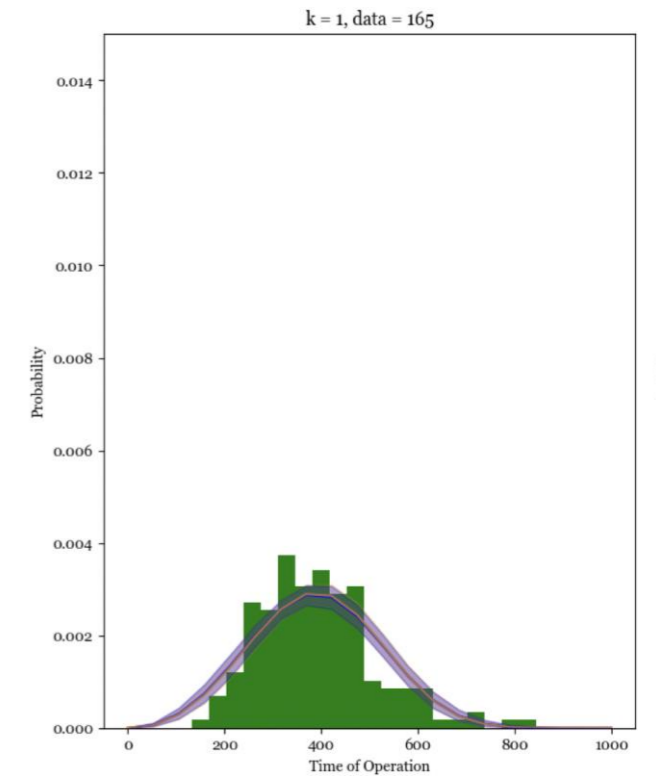
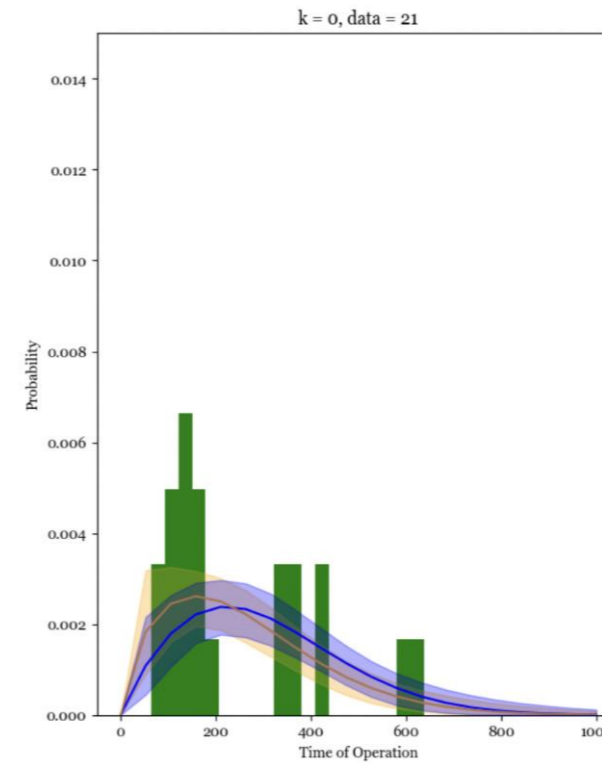
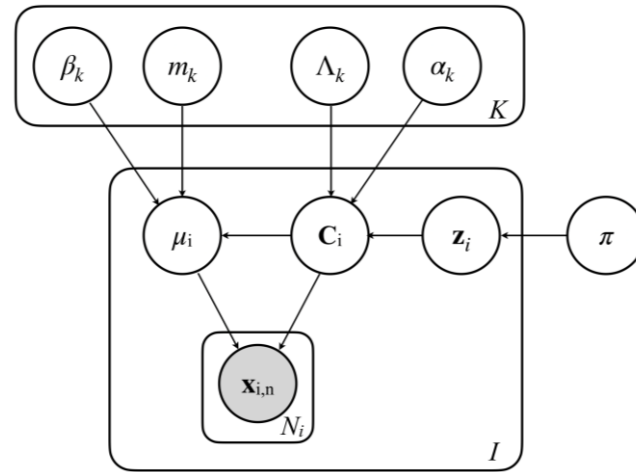


Agent system reference architecture

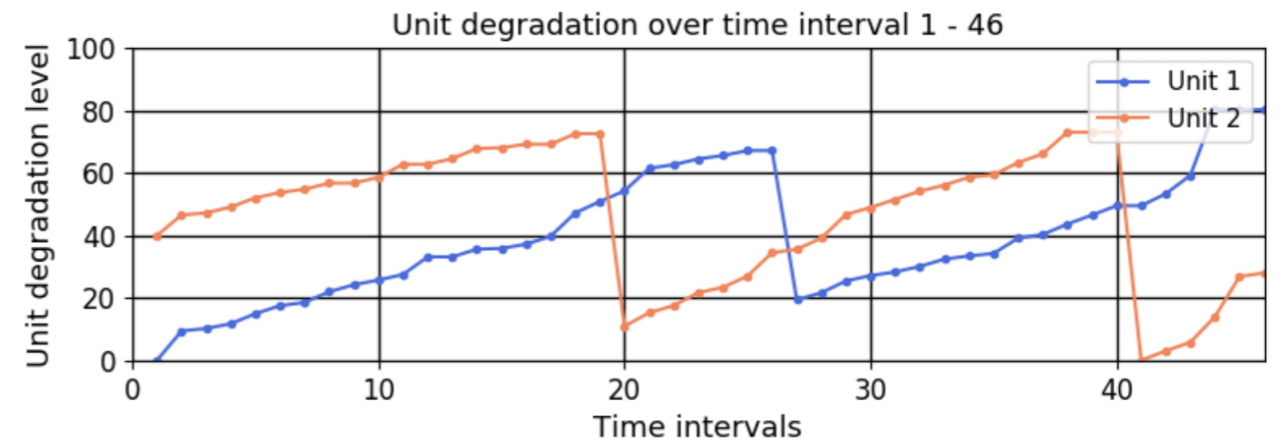
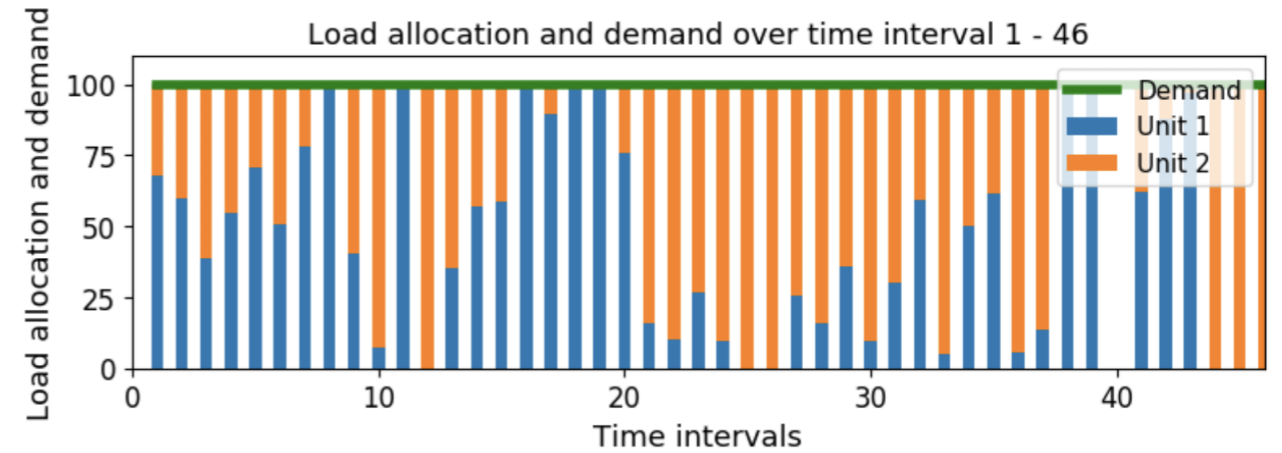
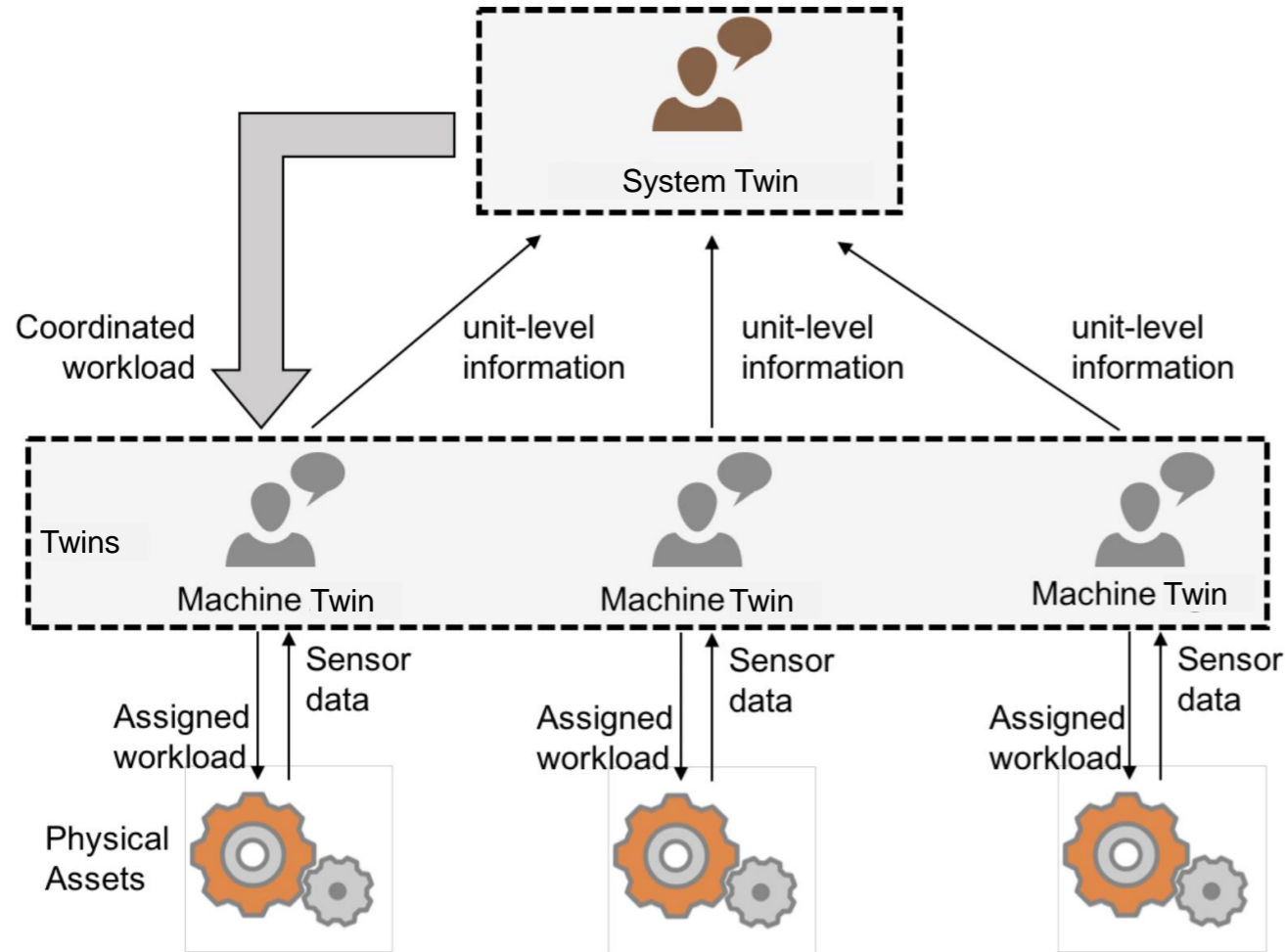
A 'social network' of digital twins can collaborate to learn failure patterns faster



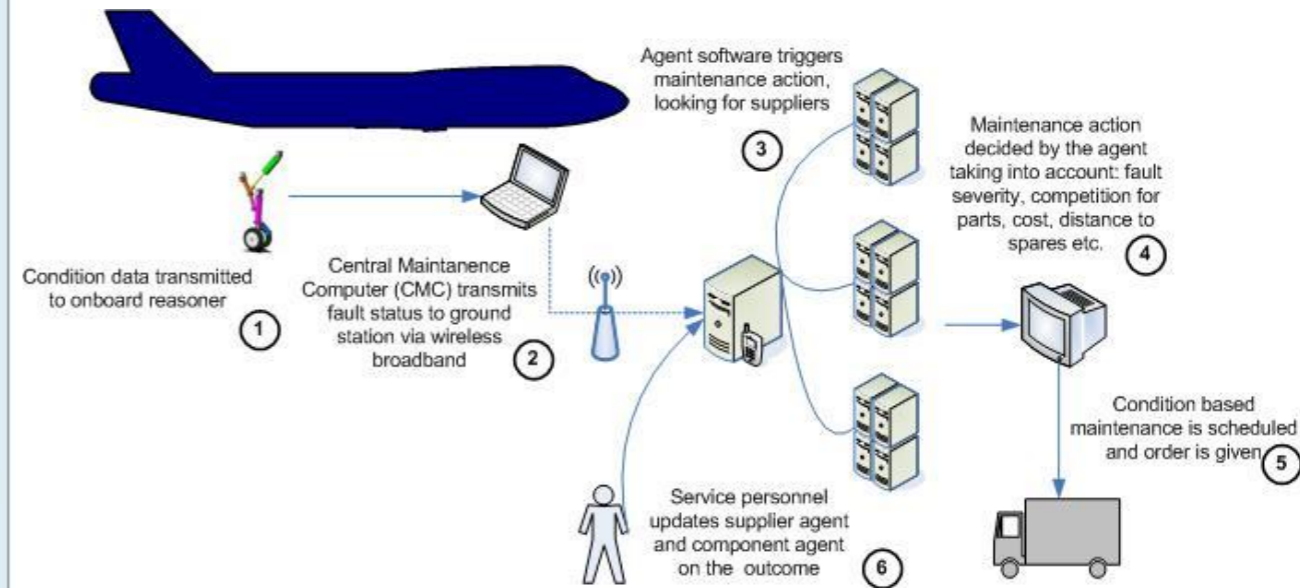
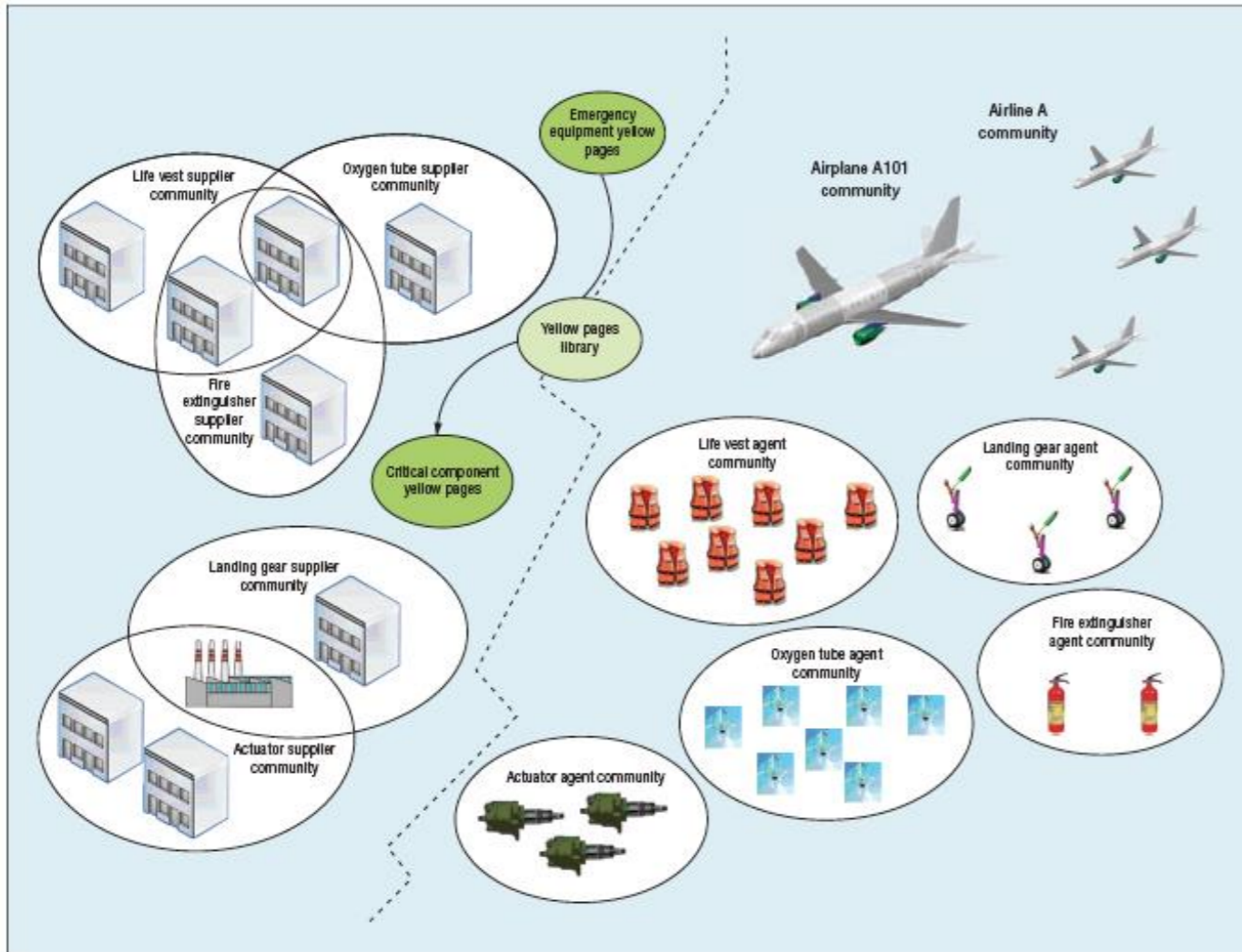
Social assets can collaborate by sharing their 'models'



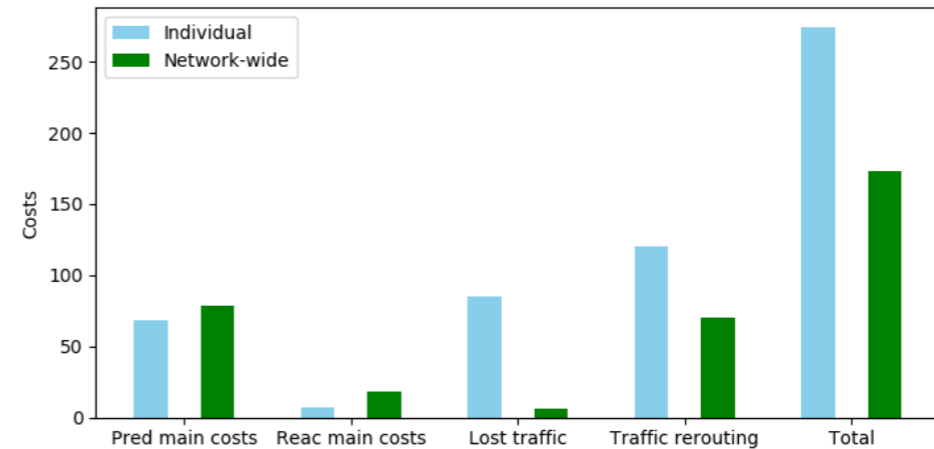
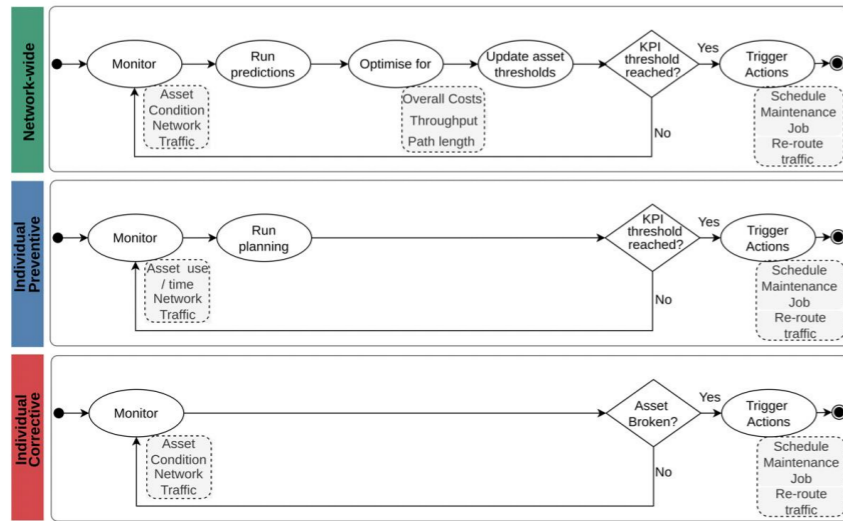
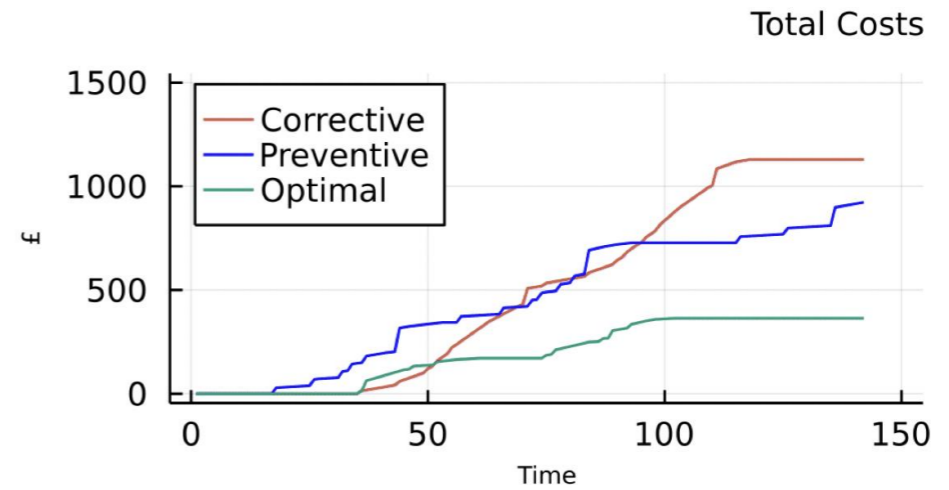
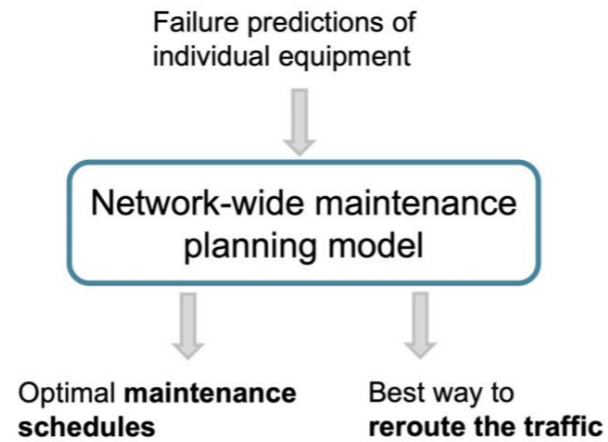
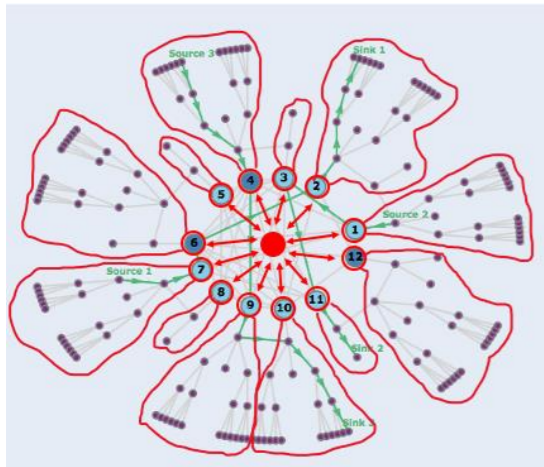
Social assets can help each other out autonomously in times of trouble



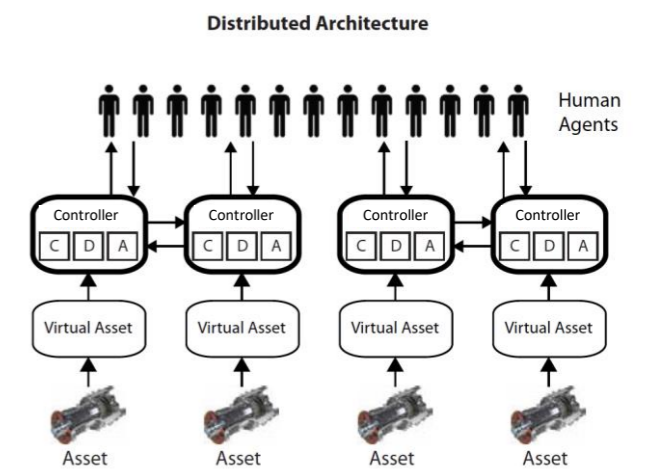
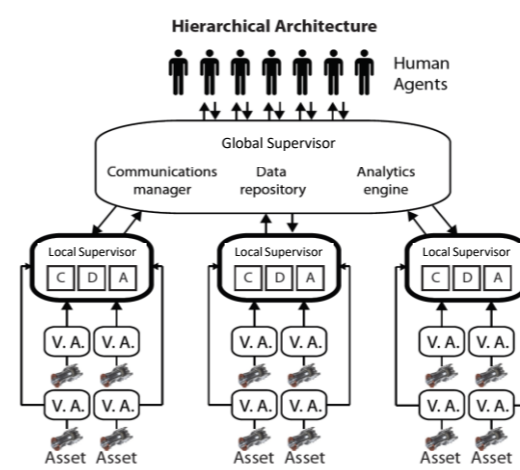
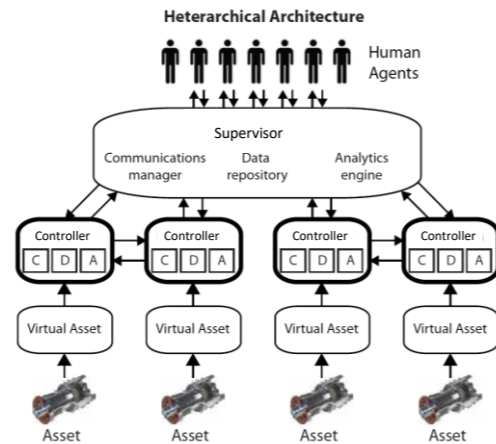
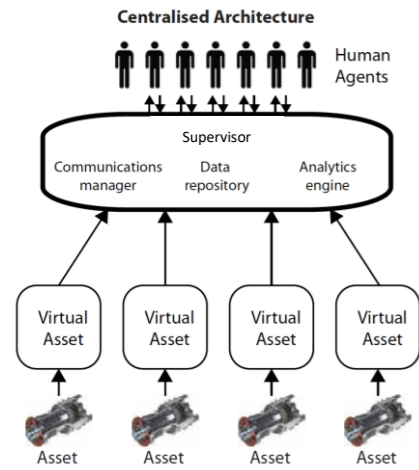
Social assets enable dynamic management of spares



Social digital twins enable network-level maintenance planning



Architectural options need to be considered carefully for implementing a digital twin ecosystem



Challenges remain...



DATA QUALITY



DEALING WITH
UNCERTAINTY



LEARNING SYSTEM
RELATIONSHIPS AND
CAUSALITIES



INTEGRATING
ASSETS AND
PROCESSES



Thank you



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