Security Level:

The explorations and challenges for AI based Fault Prediction and Prevention on ICT system

Pei Ke
Corporate Reliability Dept of Huawei 2012 Lab
peike@huawei.com
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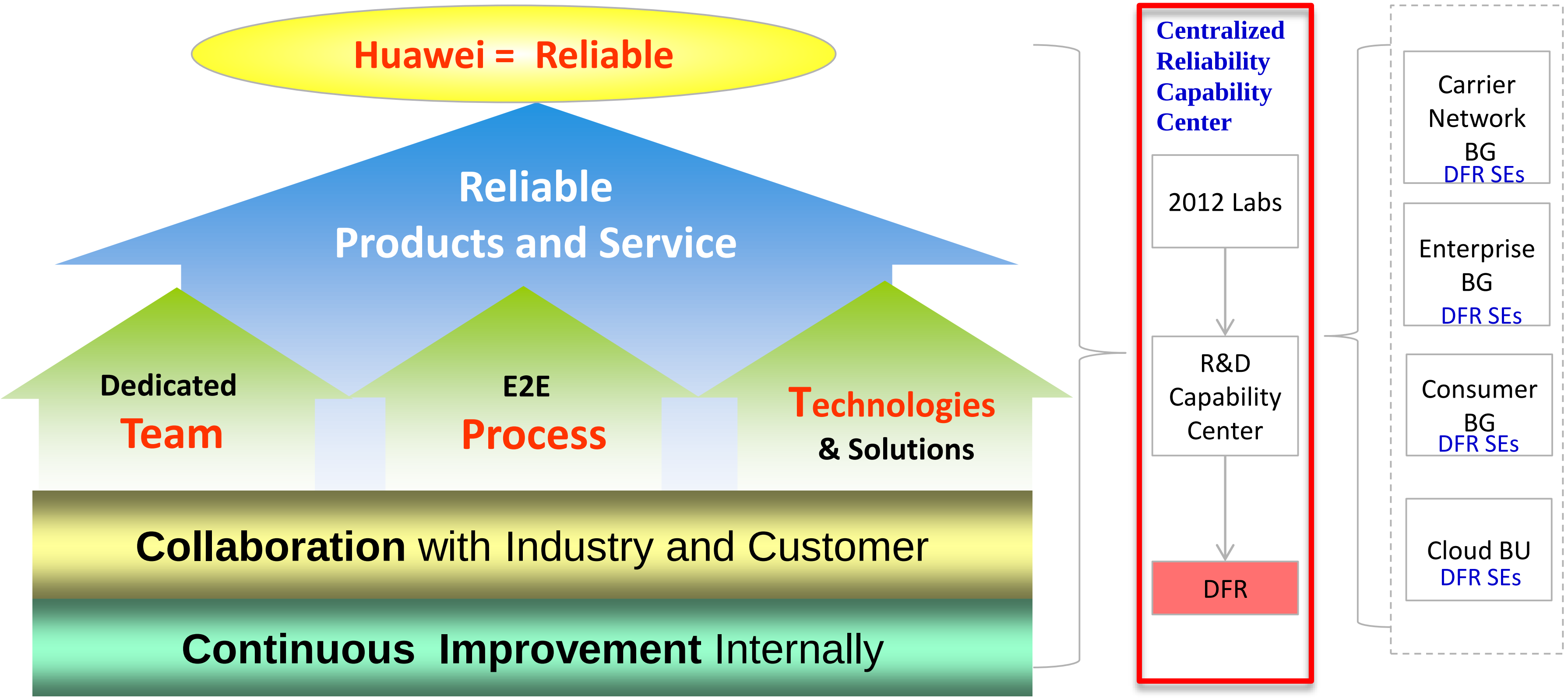
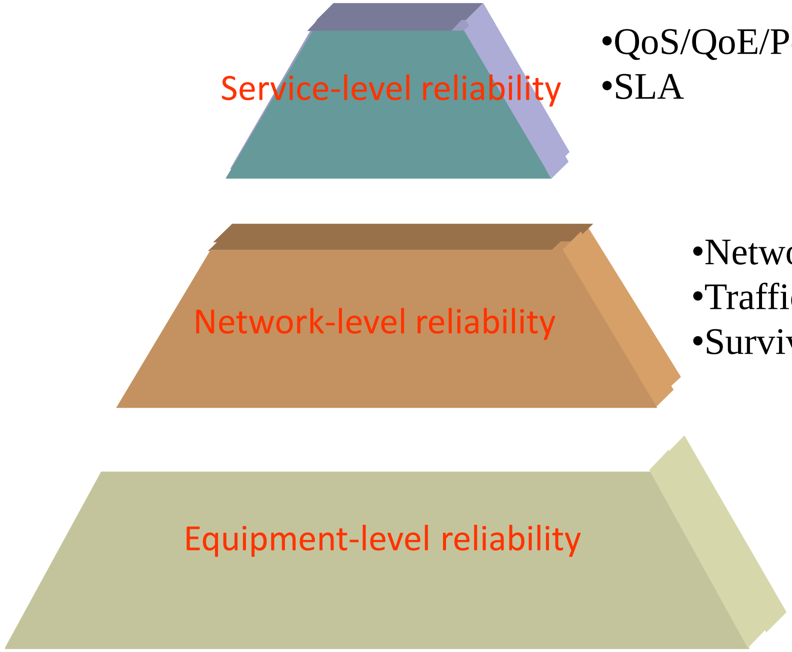
Huawei Reliability Department Introduction

- Dedicated team, Advanced technologies and solutions POC, standard , E2E process,,......
- To break the silos between products, between reliability and product R&D engineers.



Scope of Huawei Reliability



- QoS/QoE/Performance
- SLA

- Network design/Geo-Redundancy
- Traffic control/ load balance
- Survivability /Disaster Recovery

- Software reliability
- Hardware Reliability
- Mechanical Reliability

Fault Tolerant of Distributed system Cloud computing Cloud Storage	Fault Management Detect, diagnostics, Recovery	Overload control	In service upgrade

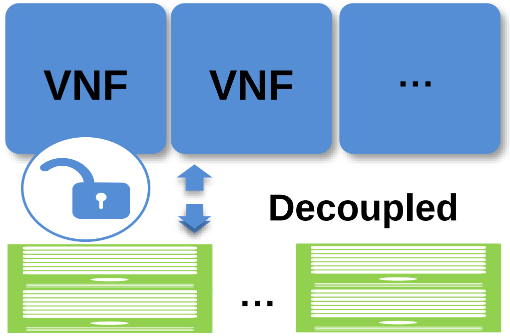
Technology, Methodology, Architecture, Design, Tools,……

Agenda

- Background
- Methodology of intelligent fault management
- The challenges and exploration

3 Levels of “All Cloud” Evolution for Telecom Industry

Virtualization



Technology

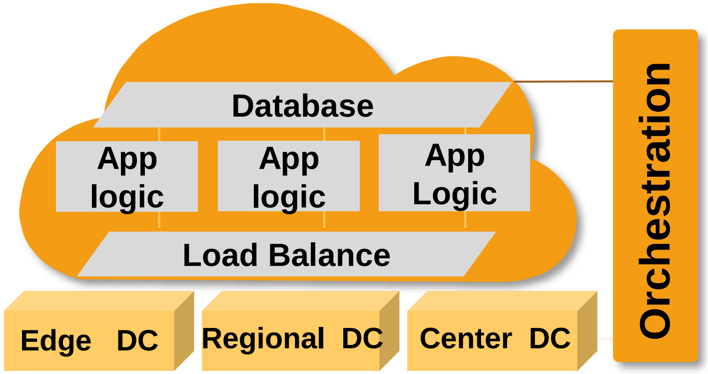
- Hardware and software decoupled

Business

Focus on SW/HW decouple

- Mass market

Cloudification

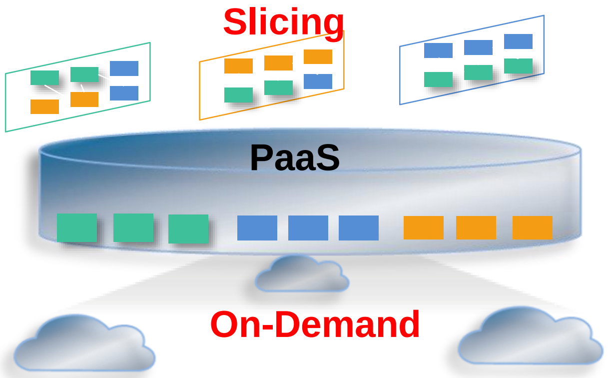


- Service Governance framework
- Stateless Design
- N-way & Cross-DC Geo Redundancy
- Graceful Scalability
- Openness with 3rd party integration

Focus on Elasticity& Resilience

- Static Slicing: MVNO, IOT, ESN…
- CloudB2B: Cloud CDN, Cloud UC, CloudVPN

Cloud Native



- 5G oriented function decomposition
- Programmable
- DevOps & JAD: service level SW publish, A/B Test, chaos monkey
- Open platform for developers

Micro Service

Focus on Business Agility

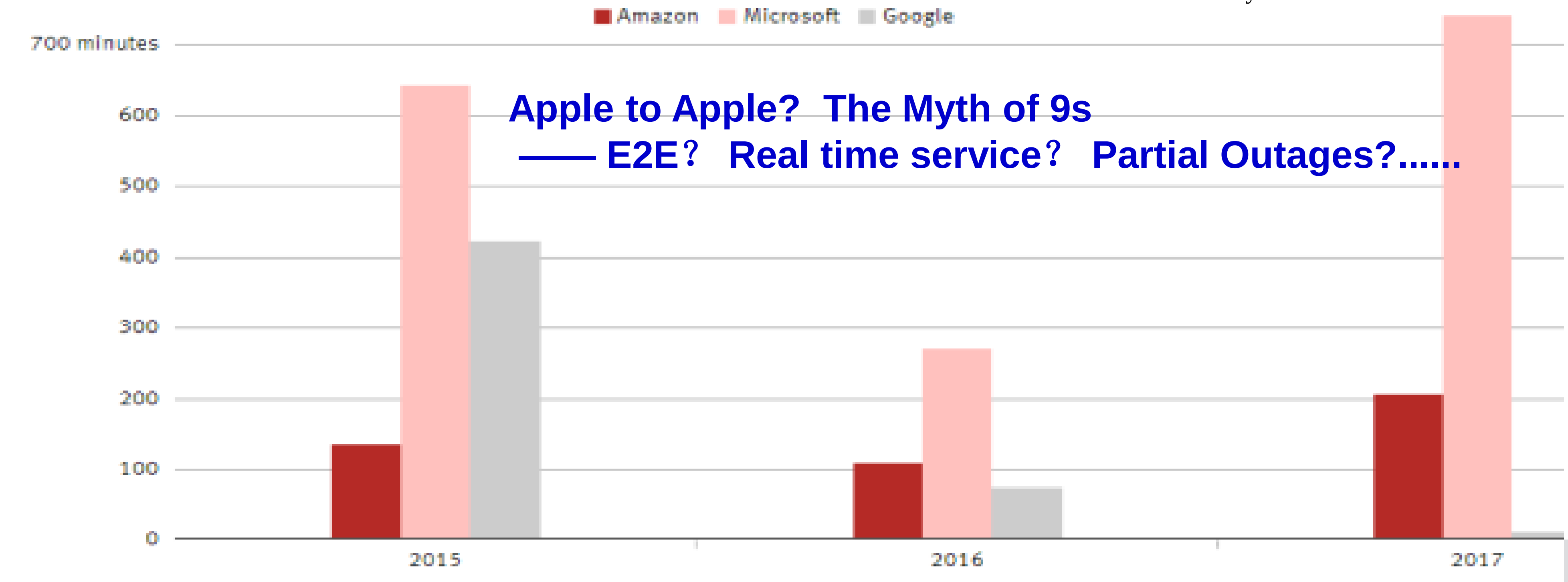
- Dynamic Slicing: AR/VR, V2X, Industry 4.0
- Market place for millions of apps

The Reality of Public Cloud Reliability

- **Google Compute Engine, 2017-01-30, 4hrs**
- **AWS's S3 outage, 2017-02-28, 4hrs**
- **Facebook, 2017-02-24, 3hrs**
- **Microsoft Azure Storage loses power for eight hours due to "software error" , 9hrs, 2017- 03-16**
- **Microsoft Office 365, 17hrs, 2017- 03-21,**
- **Apple's iCloud backup outage, 2 days, 2017- 06-28**

Actually there are much more outages happened, far more the ones list here.

Source: CloudHarmony



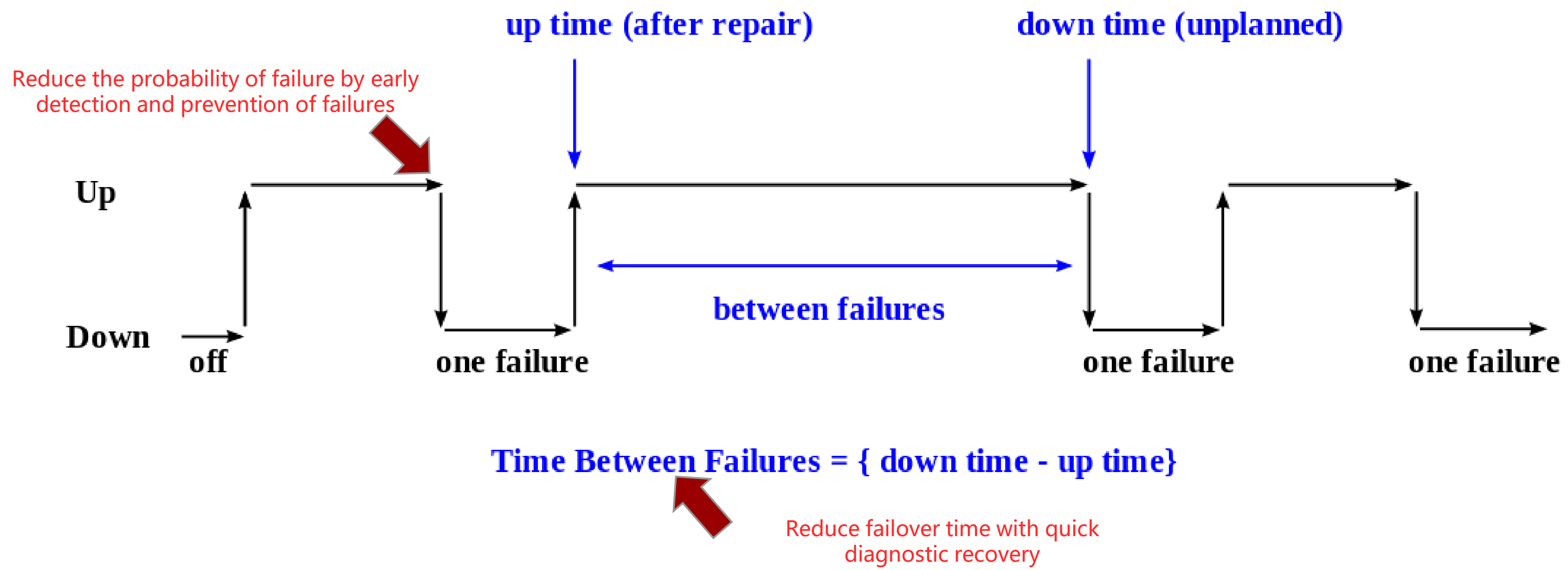
Apple to Apple? The Myth of 9s

—— E2E？ Real time service？ Partial Outages?......

How to improve it?

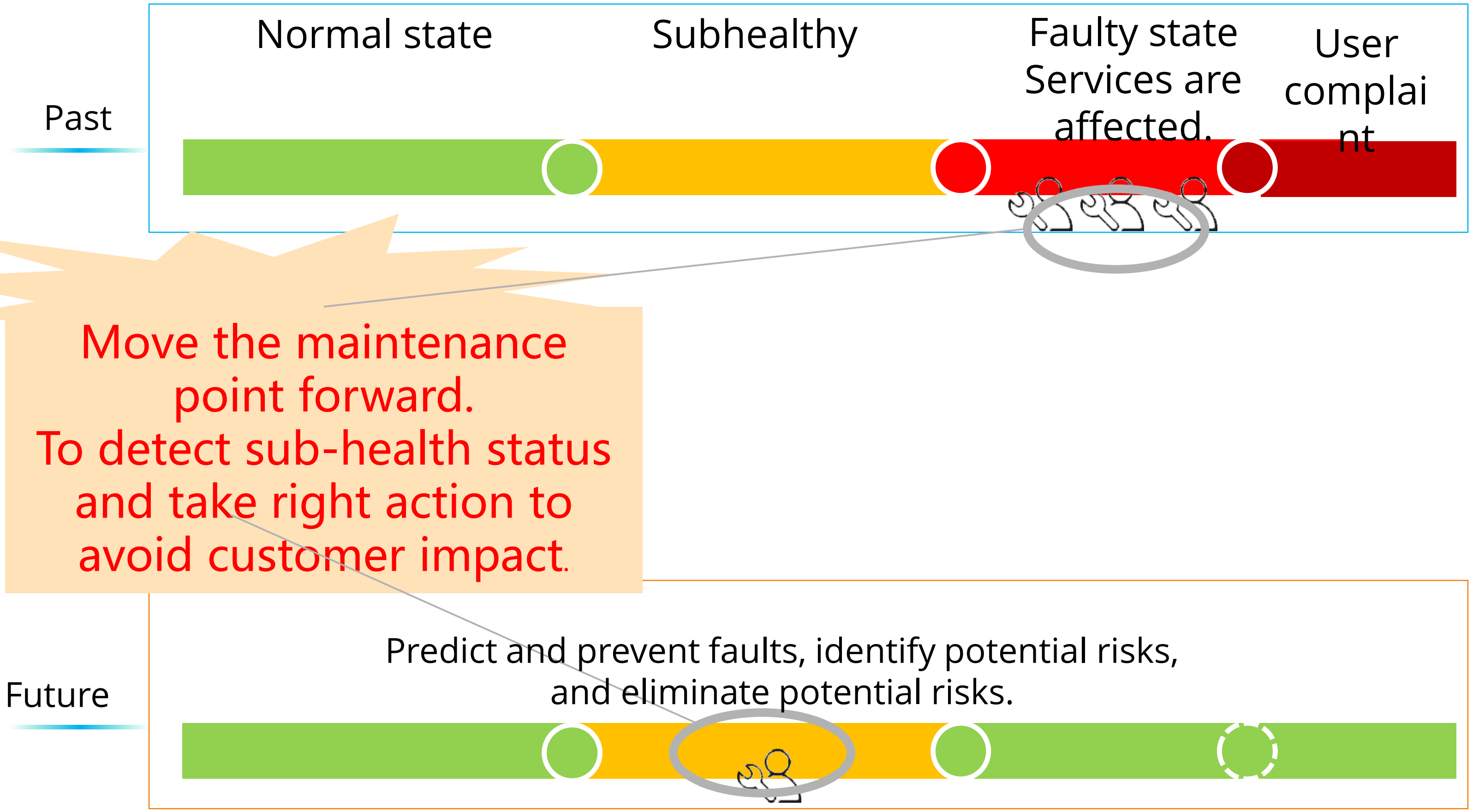
- MTBF(Mean Time Between Failures)： $MTBF = \frac{\sum\{(downtime)_n - (uptime)_{n-1}\}}{\text{number of failures}}$
- MTTR(Mean Time To Repair)： $MTTR = \frac{\sum\{(uptime)_n - (downtime)_n\}}{\text{number of failures}}$
- A(Availability) = ： $\frac{MTBF}{MTBF+MTTR} = \frac{\text{total time} - \sum(\text{time to repair}) * (\text{number of failures})}{\text{total time}}$

The smaller, The better



Idea：From Fire-Extinguishing to Fire-Prevention

Health status and maintenance flow



Move the maintenance point forward.
To detect sub-health status and take right action to avoid customer impact.

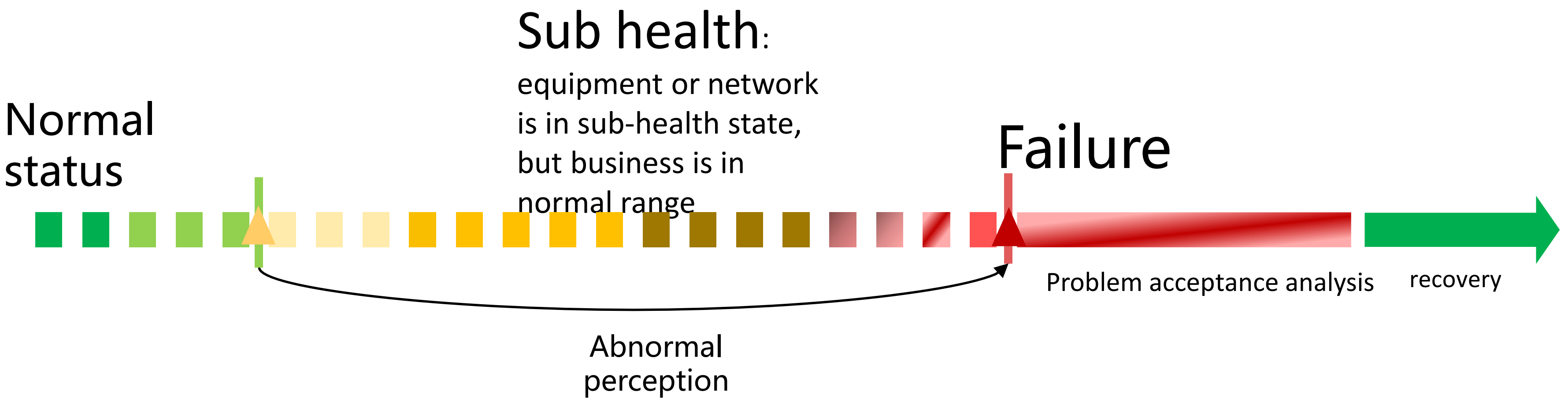
Reactive approaches

– No prevention cost
– but prolonged service downtime

Proactive approaches

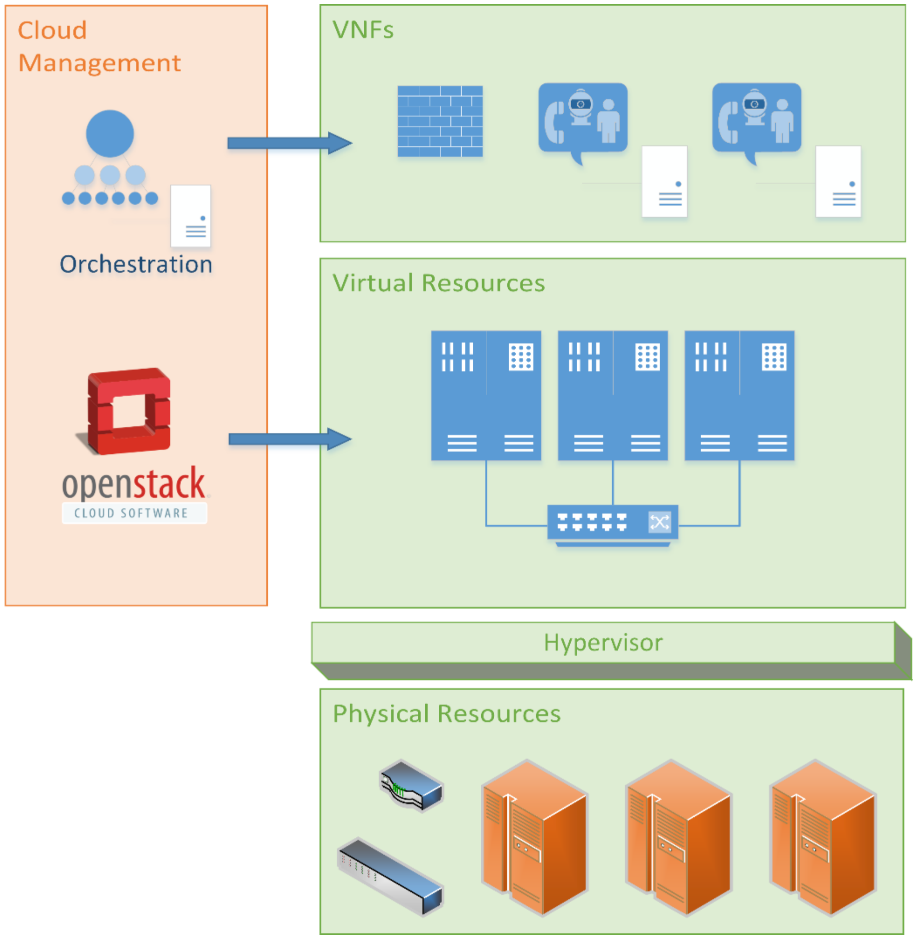
–Provide better system reliability
–but incur large overhead

Our Vision

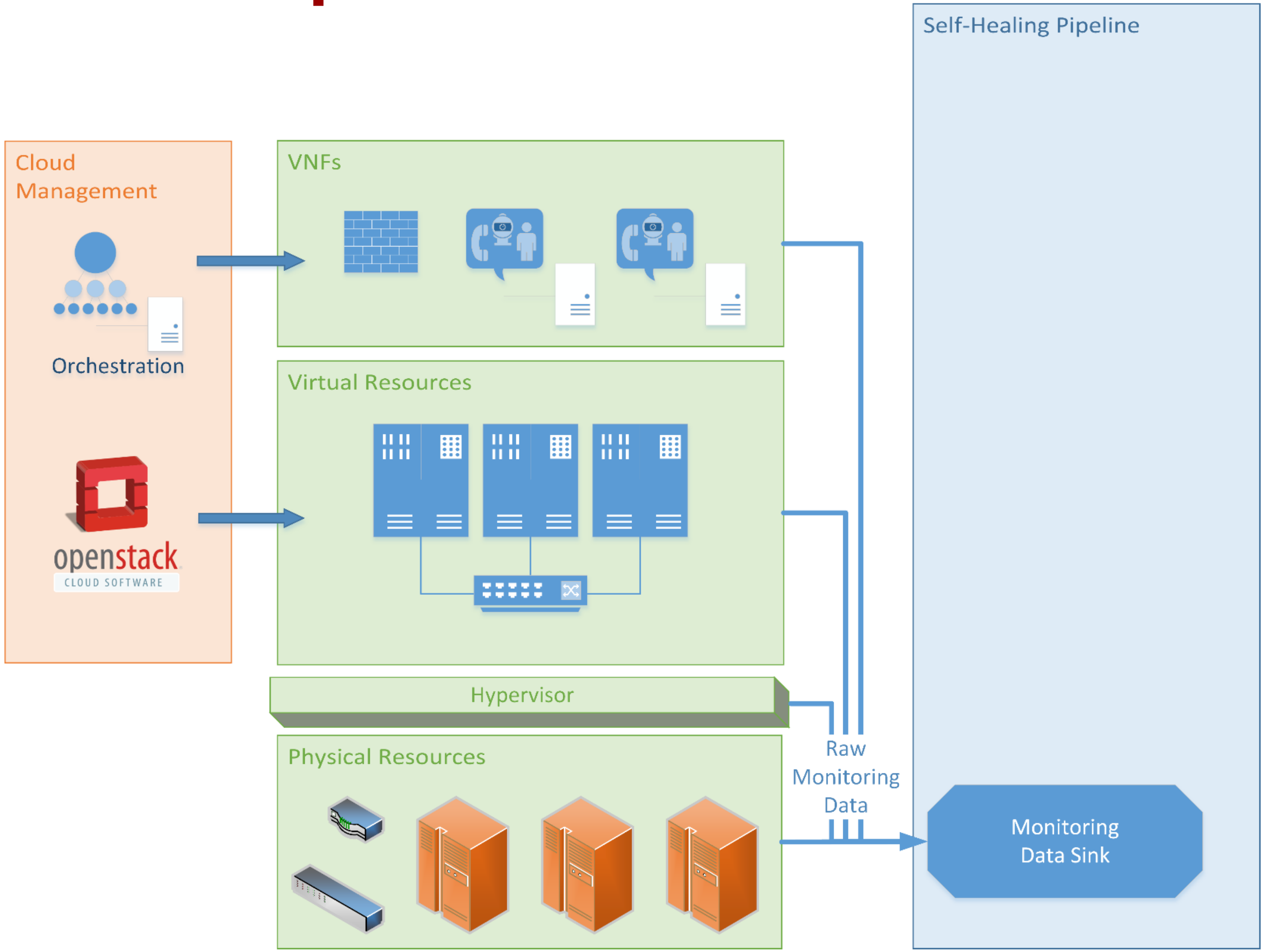


Level 1: Data pipeline is ready or not
Level 2: AI knows abnormal or not?
Level 3: AI knows “what happened? ”
Level 4: AI can knows ” what will happen? ”
Level 5: AI can suggest” what action need to be taken? ”, which are carried out manually.
Level 6: full automation enables self-healing.

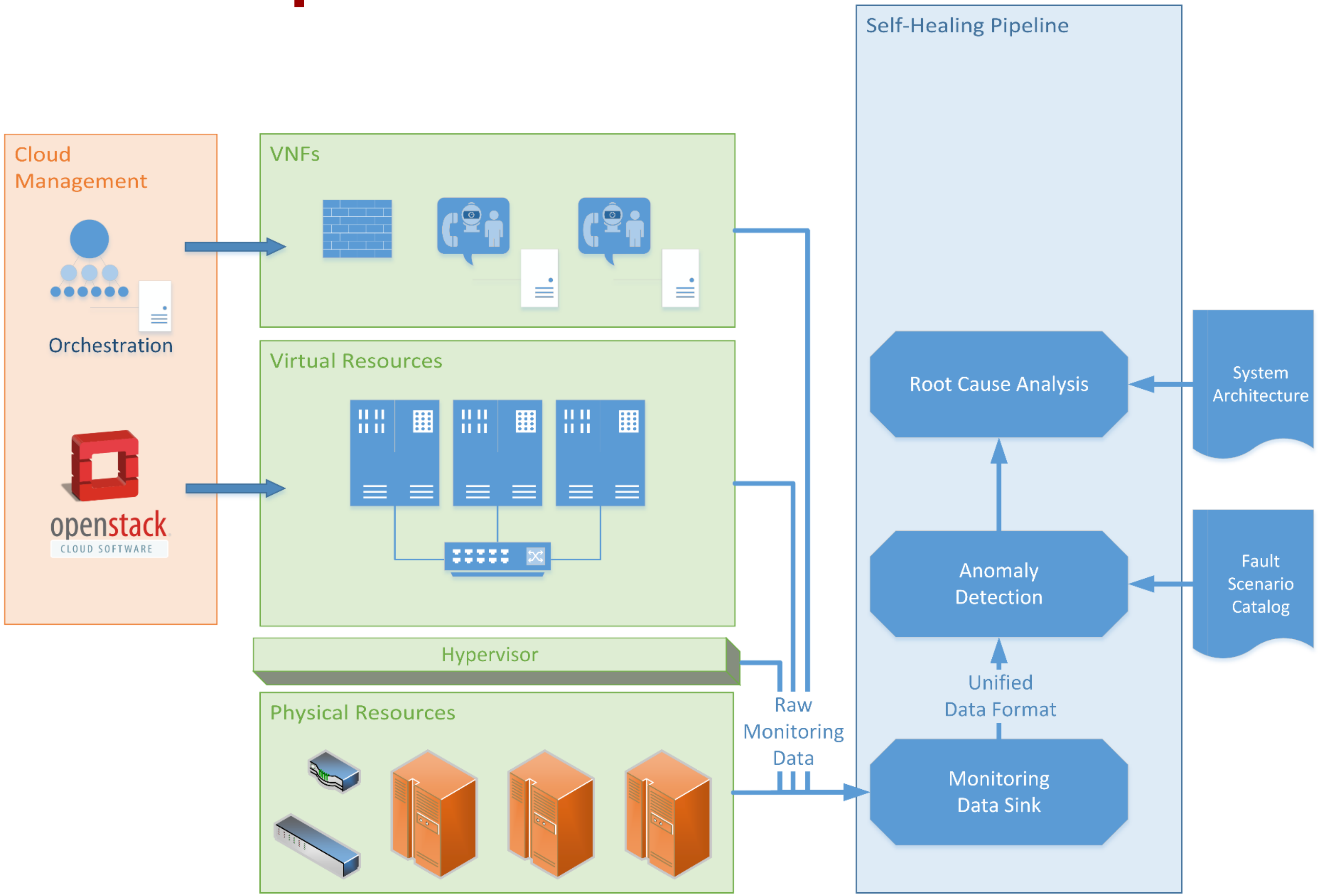
FPP Evolution path



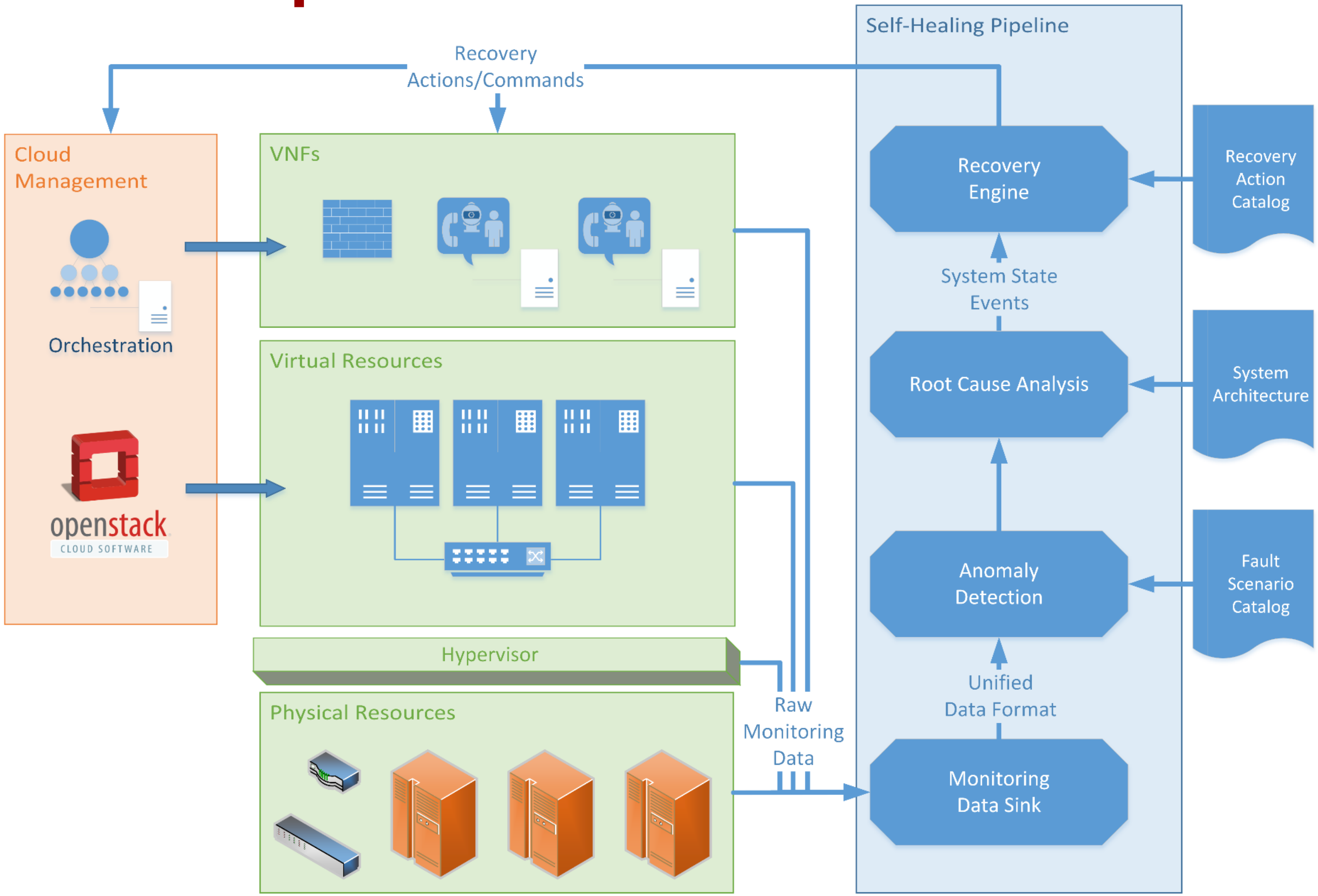
FPP Evolution path



FPP Evolution path



FPP Evolution path



Agenda

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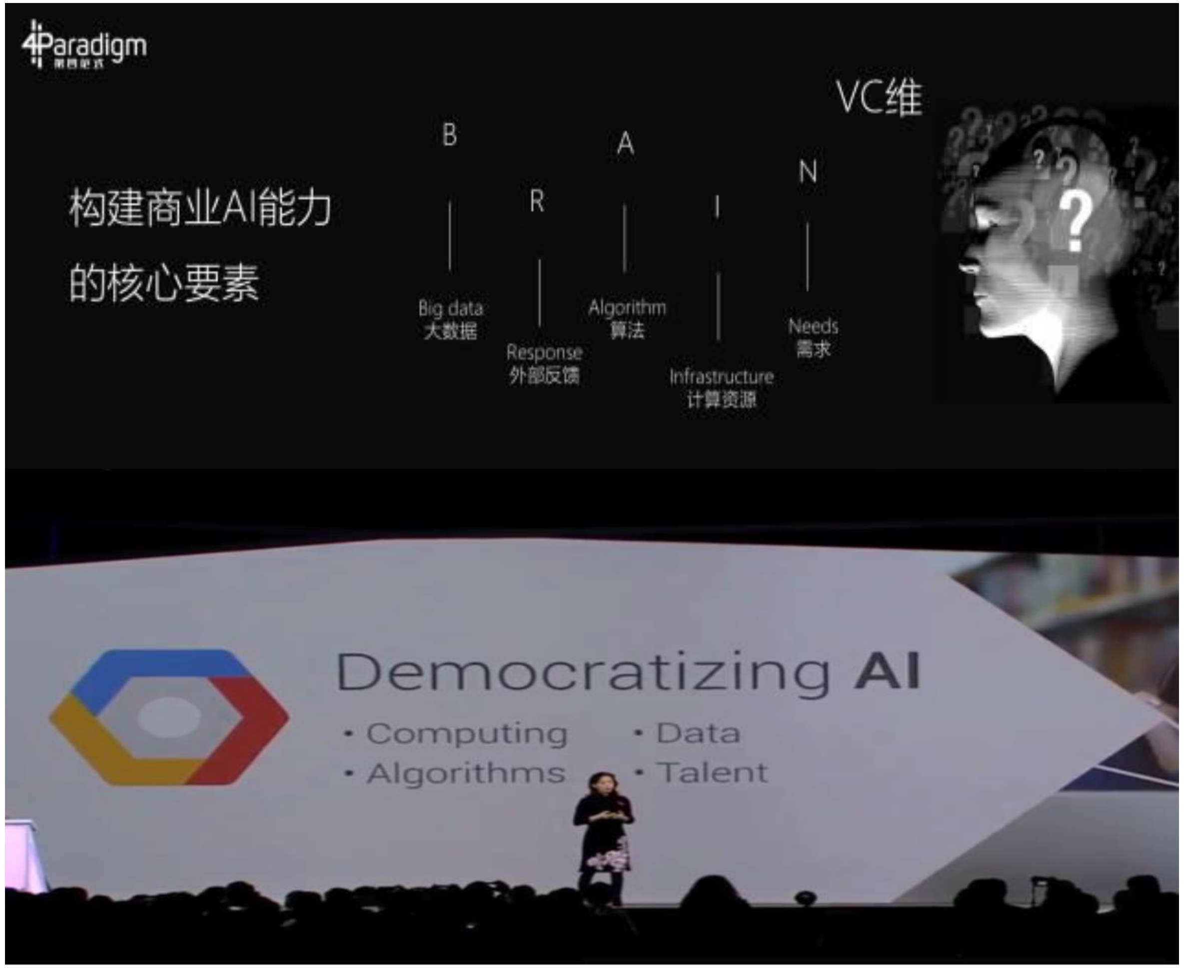
- Methodology of intelligent fault management
- The challenges and exploration

Three elements of AI project success



Data:

Algorithms without data are useless. Data is the core of the algorithm, so getting a lot of data will become the top priority.

Algorithm:

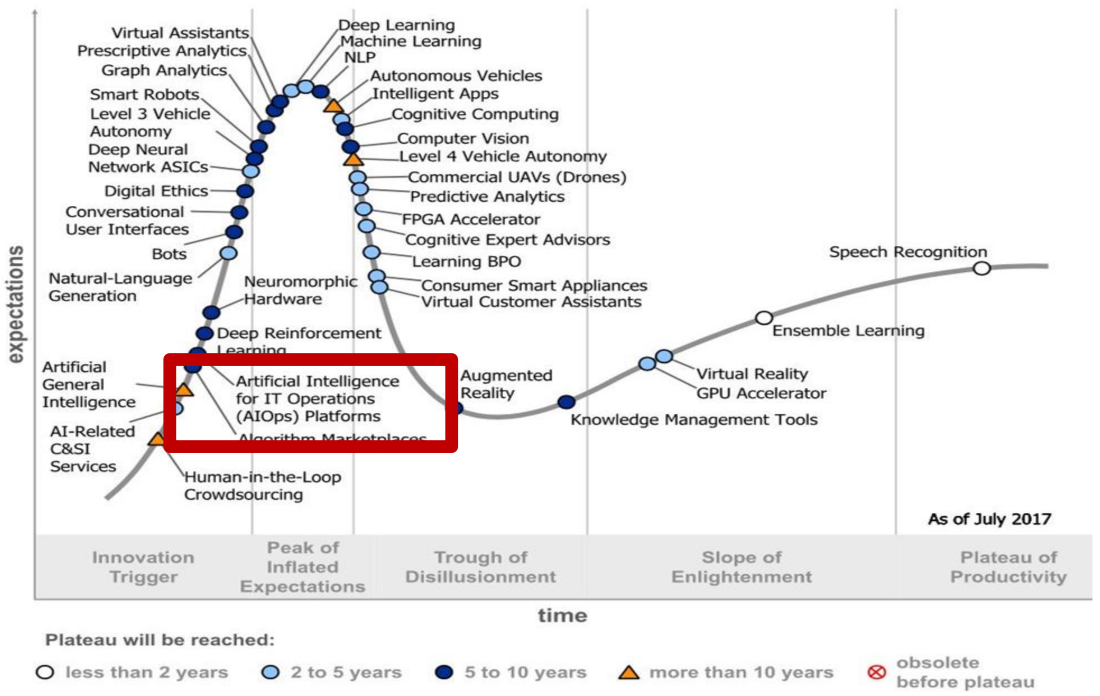
Google acquired DeepMind to gain competitive advantage. FB has acquired Wit.ai to enhance speech recognition and voice interface services

Computing power:

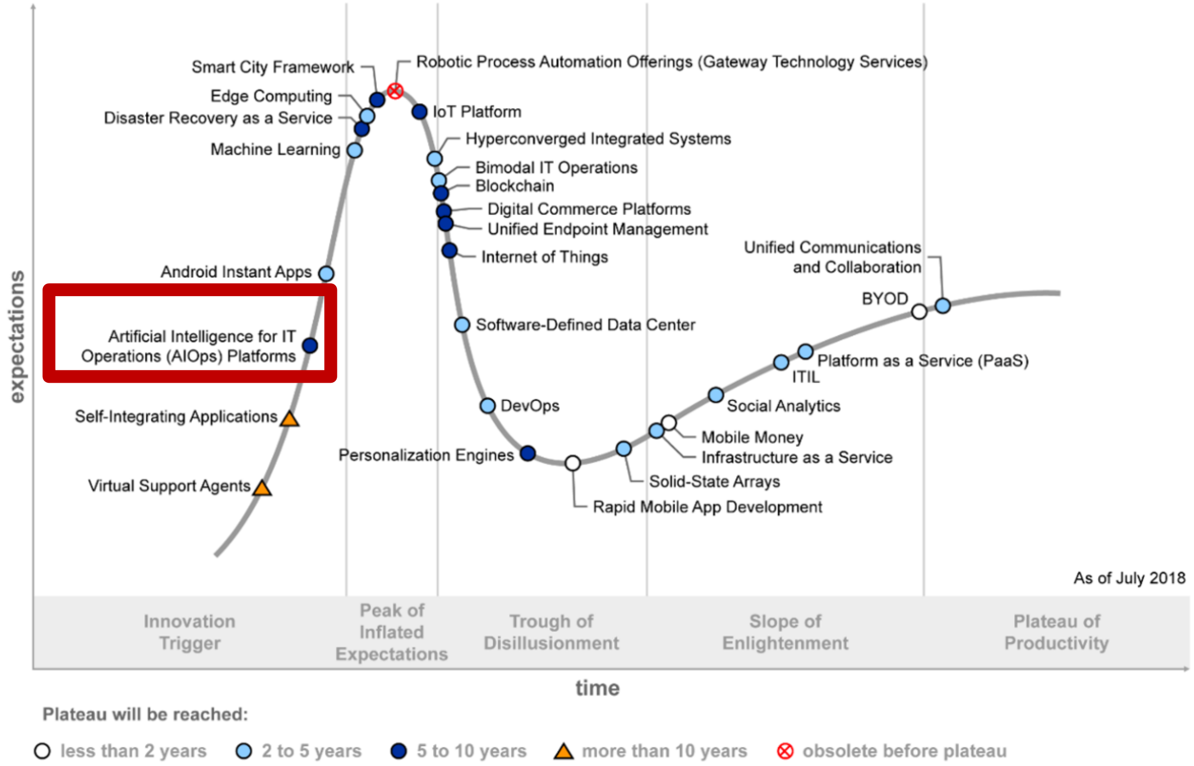
Google TPU	2016.5
NVIDIA Tesla P100 GPU	2016.4
Microsoft FPGA	2016.9
HW Ascent910/310	2018.10

Gartner Hype Cycle state

Gartner think it’s in “Innovation trigger” stage from 2017 to now, no change , It need takes five to ten years to mature. So pessimistic ?

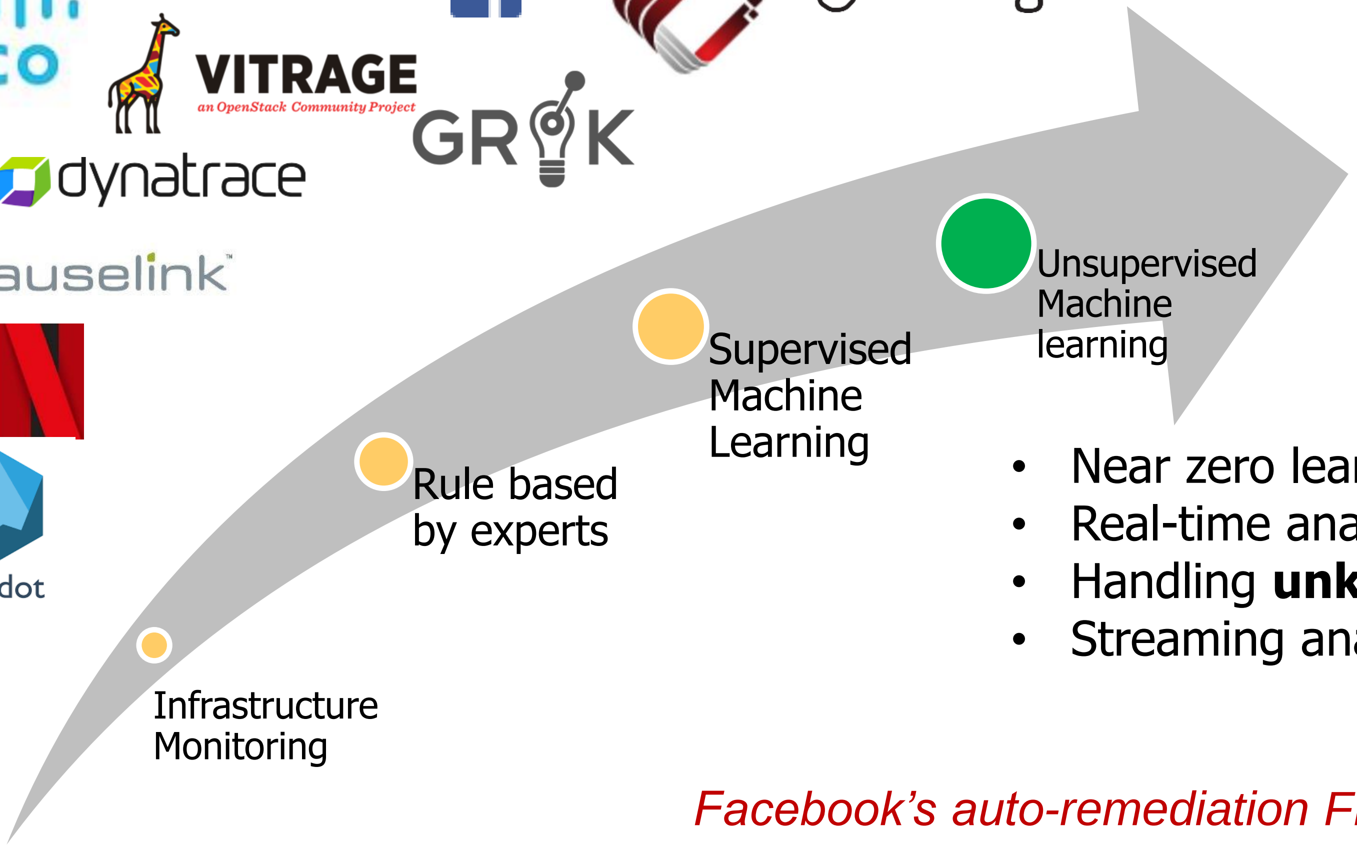


Source: Gartner Hype Cycle for artificial intelligence 2017



Source: Gartner, Hype Cycle for ICT in India, 2018

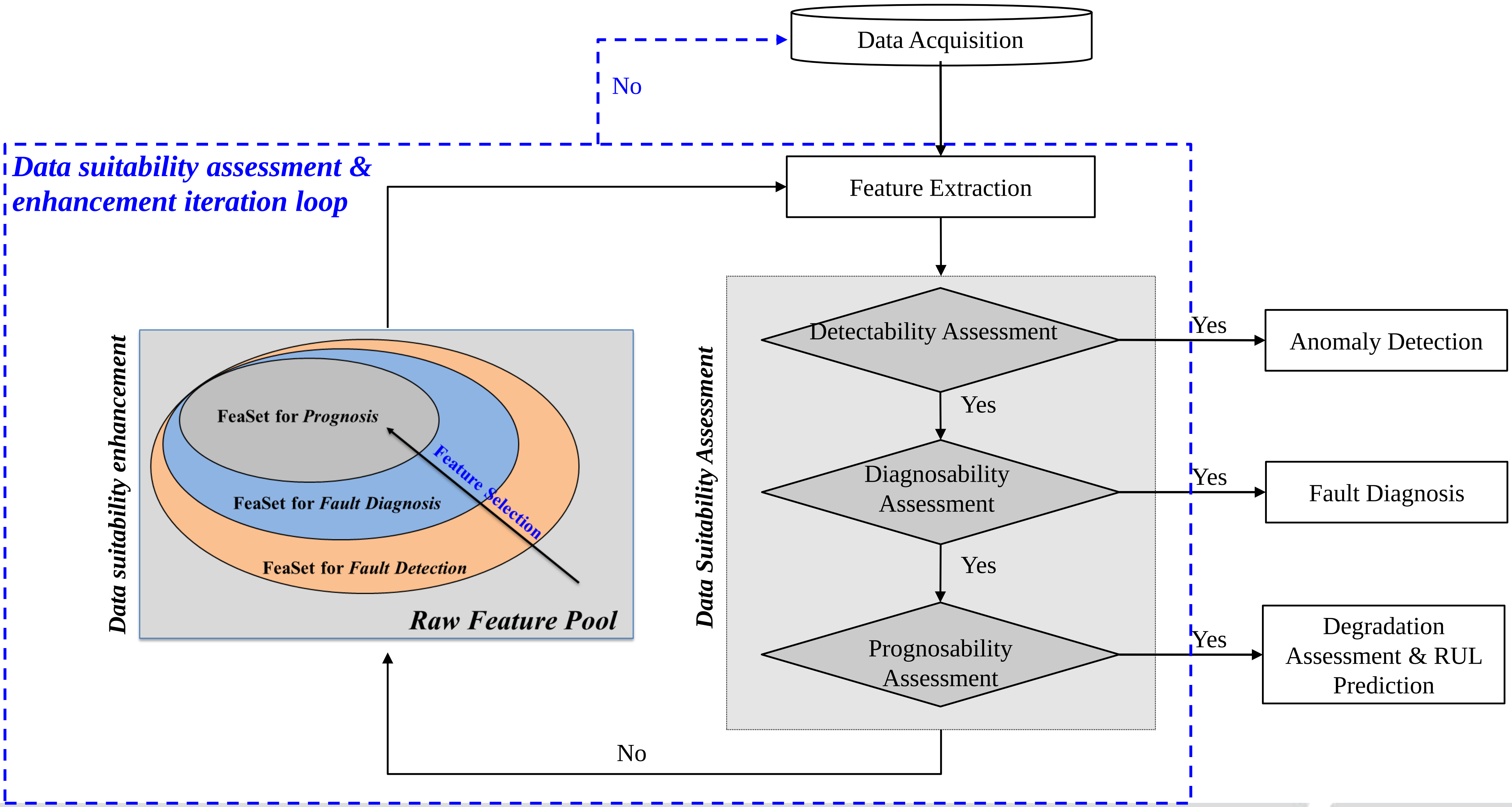
Industry players



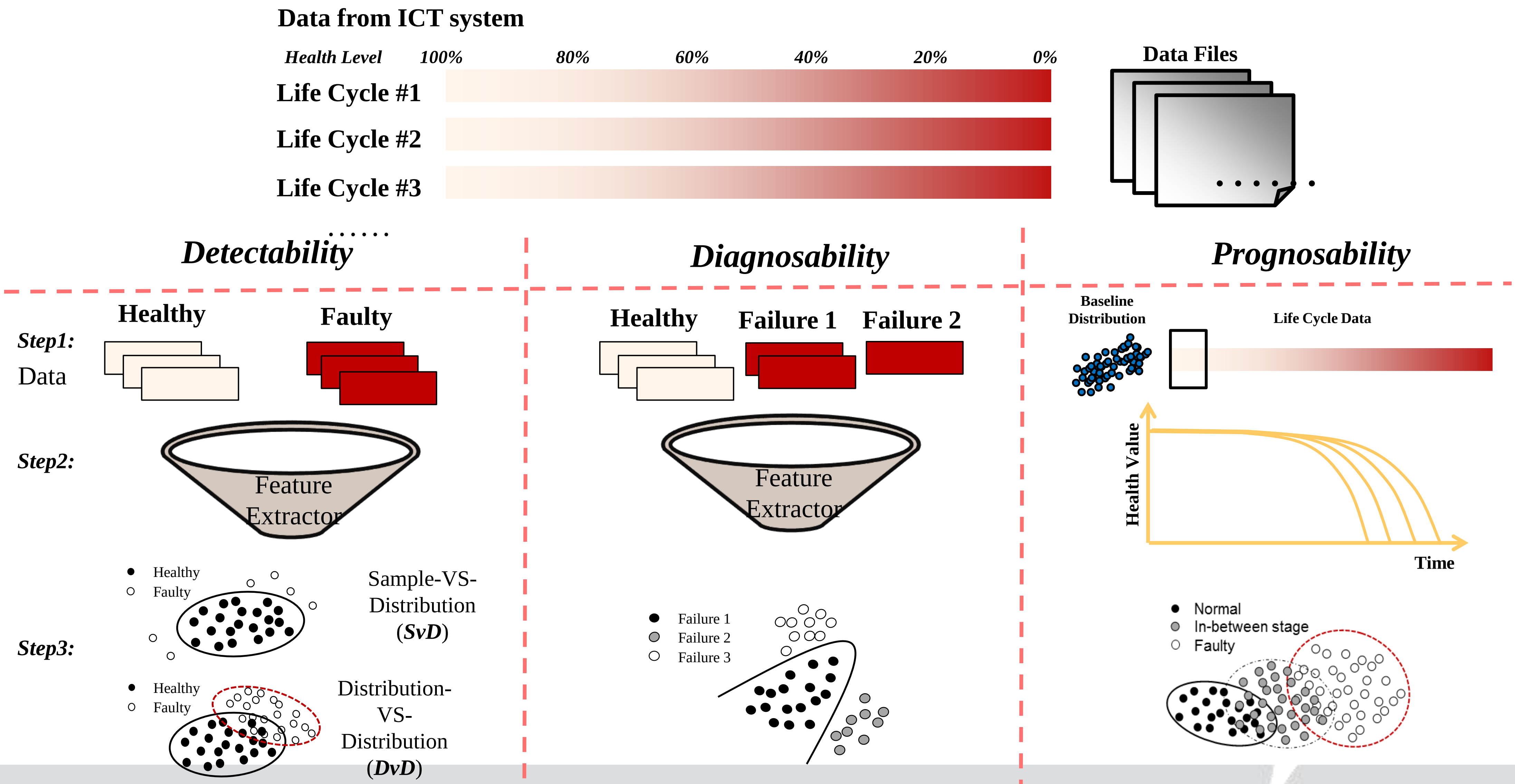
- Near zero learning time
- Real-time analysis
- Handling **unknown anomalies**
- Streaming analysis

Facebook's auto-remediation FBAR and Winston system by Netflix ⇒ no technical details available

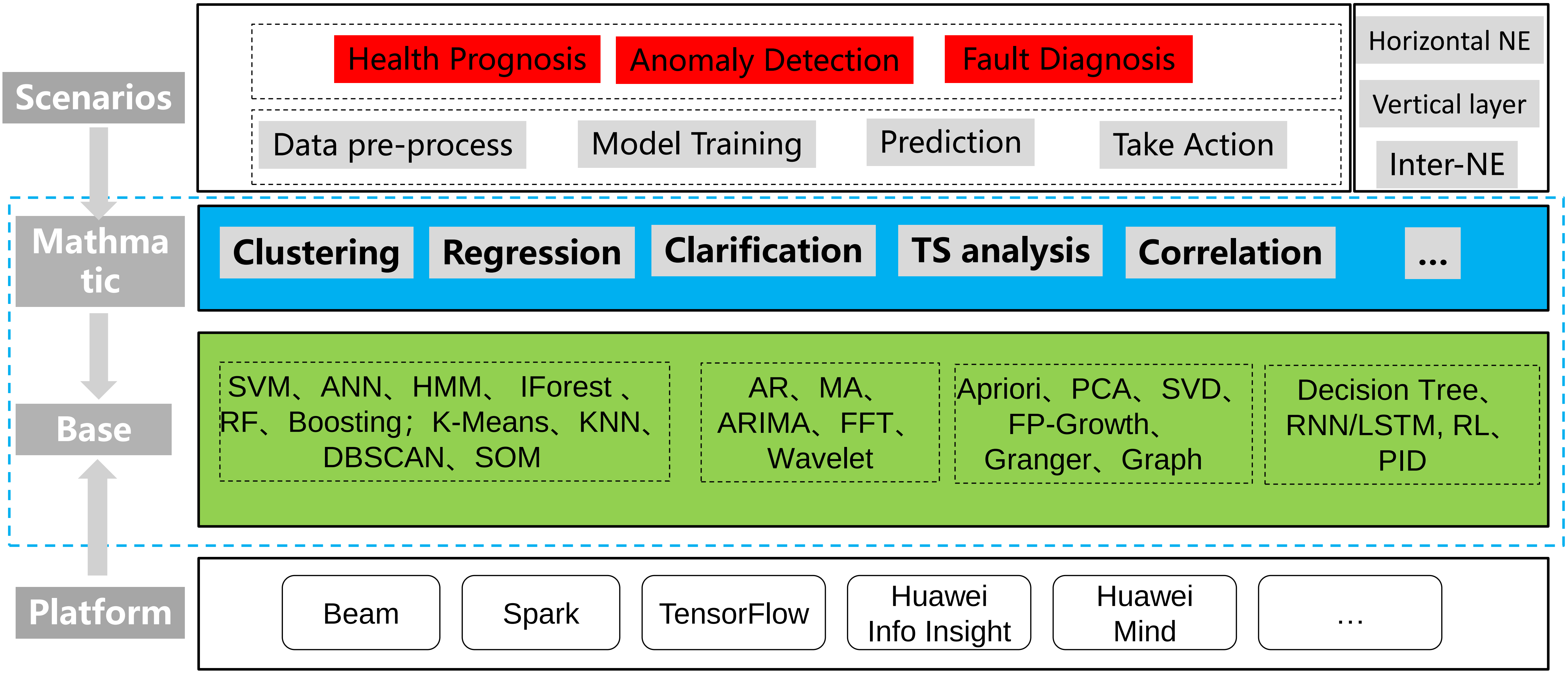
Methodology -- An Overview of FPP data pipe



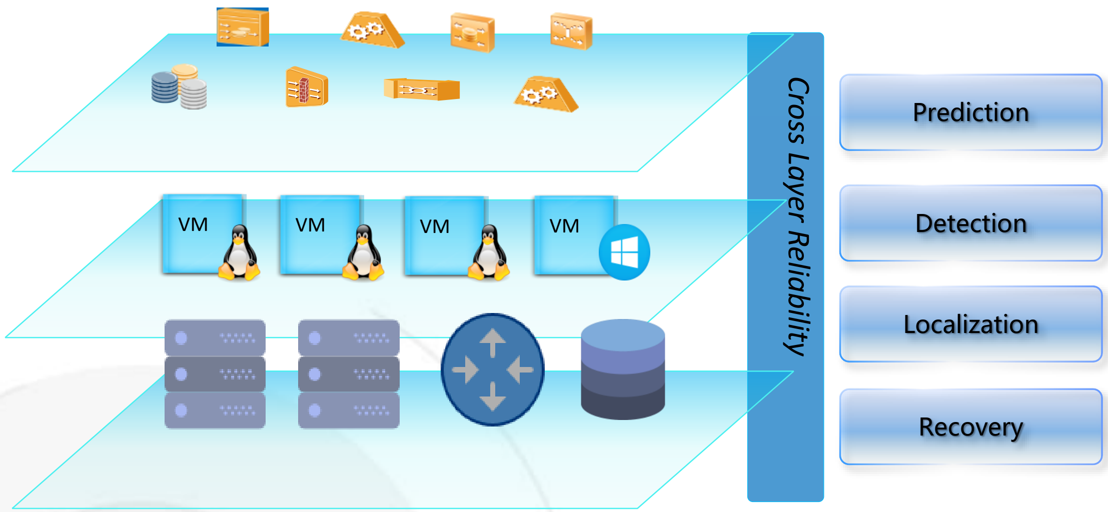
Methodology – Data Exploration of FPP data pipe

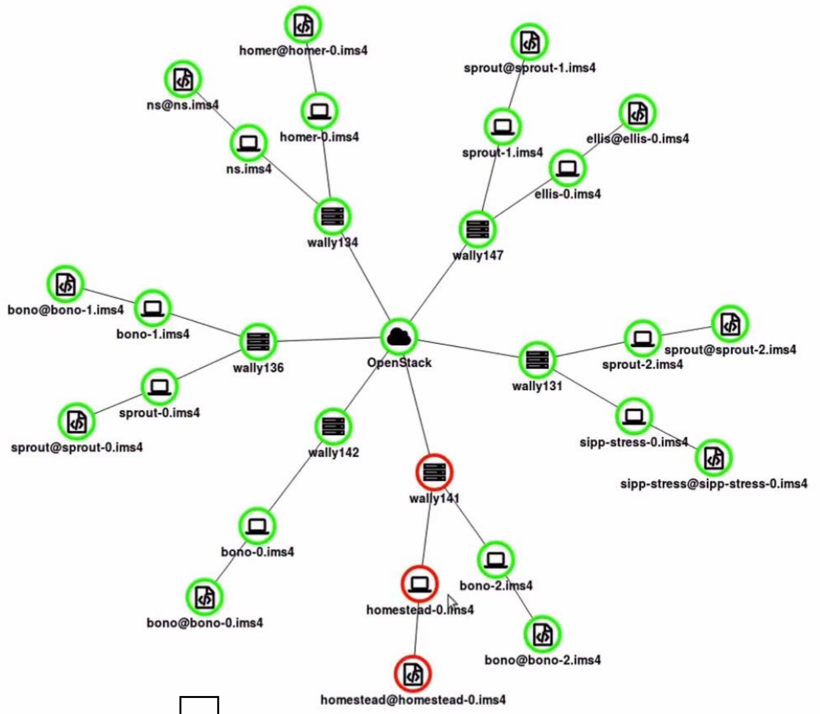


Algorithm Selection: The algorithm is widely used

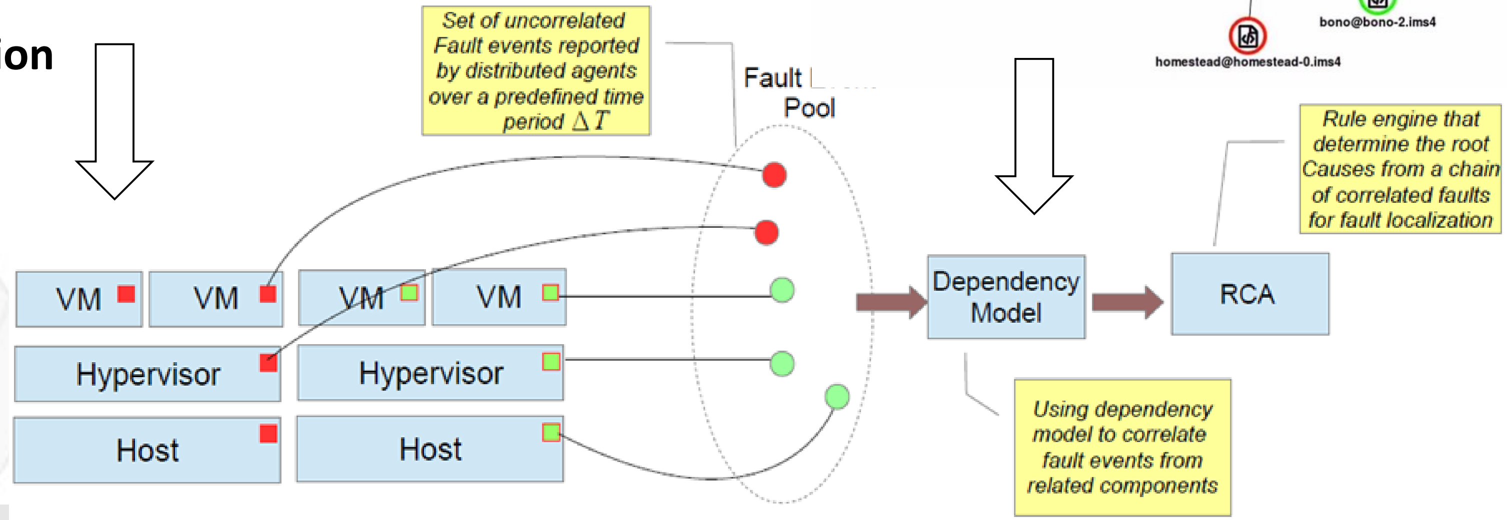


Case Study. NFV Cross Layer fault localization





Cross layer fault localization is a big challenge



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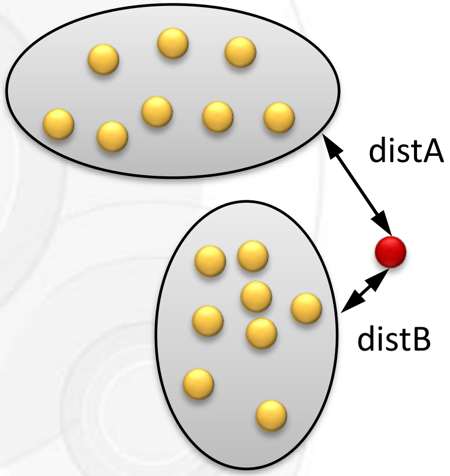
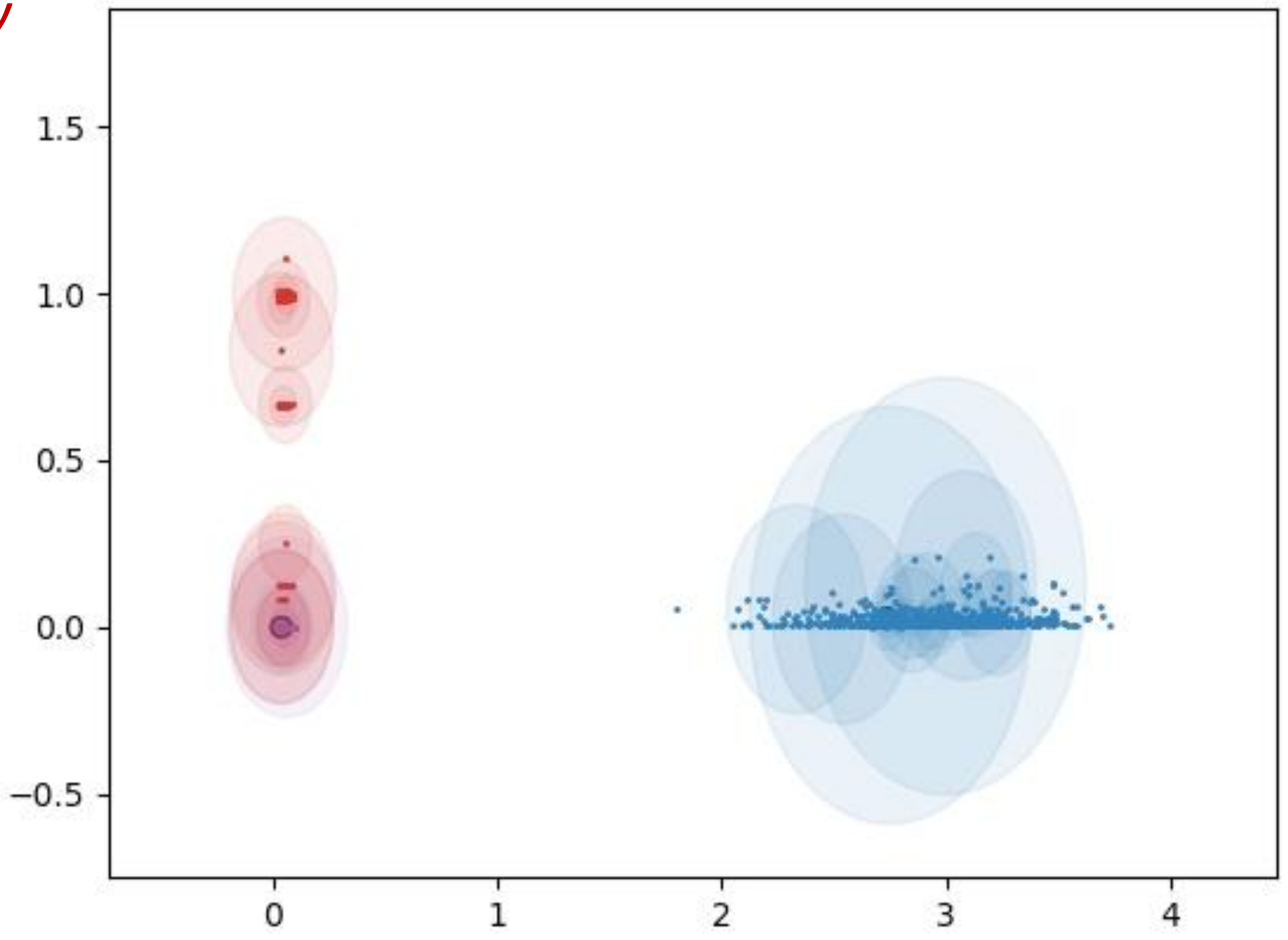
Case Study. NFV Cross Layer fault localization

Learn <u>normal</u> system state and identify deviations as anomalies

Root cause of the fault is judged according to the deviation degree of each operation environment factor



Accuracy: 0.96



Agenda

- **Background**
- **Methodology of intelligent fault management**
- **The challenges and exploration**

The real challenge is data

Garbage in, Garbage out： The quality and integrity of data is crucial for building an efficient model of AI

Hard to acquisition

- fewer commercial sites
- Data is **sensitive** and hard to access to analysis
- A small amount of fault data **can not be deposited for long time**

small data samples , unlabeled and unbalanced.

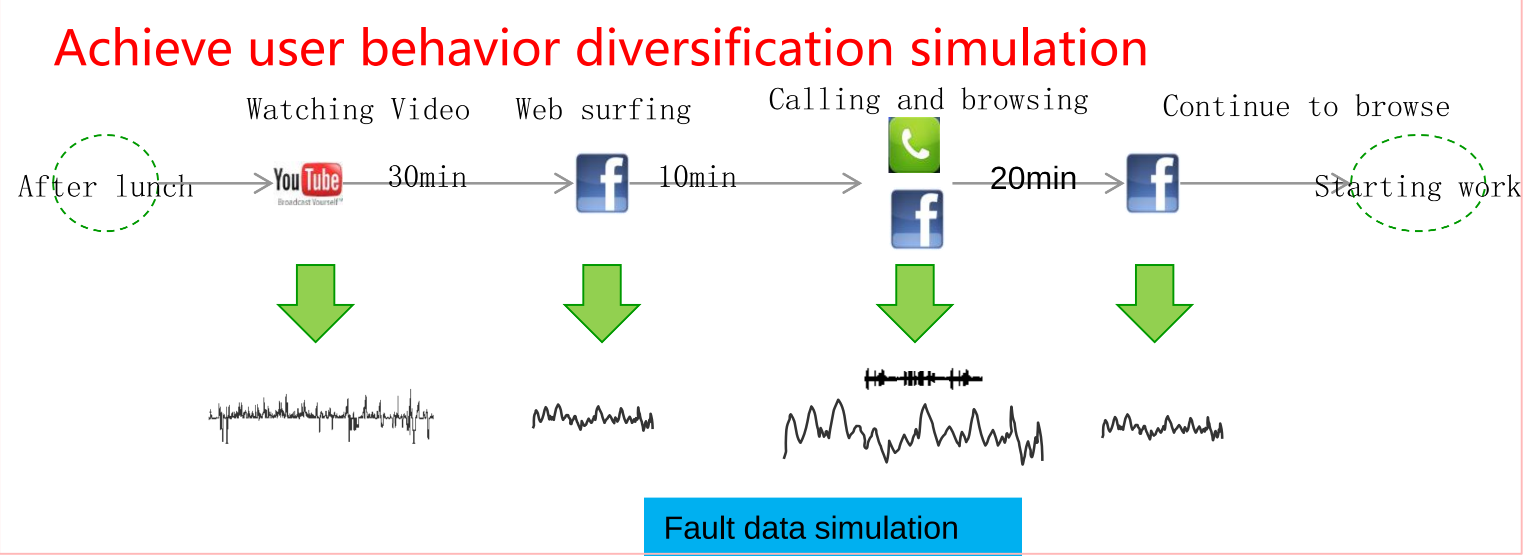
- **labeled fault** data is difficult
- There are many problems type, but **few sample data** for each.
- The fault problem of existing network is complex, which requires a lot of resources to locate.

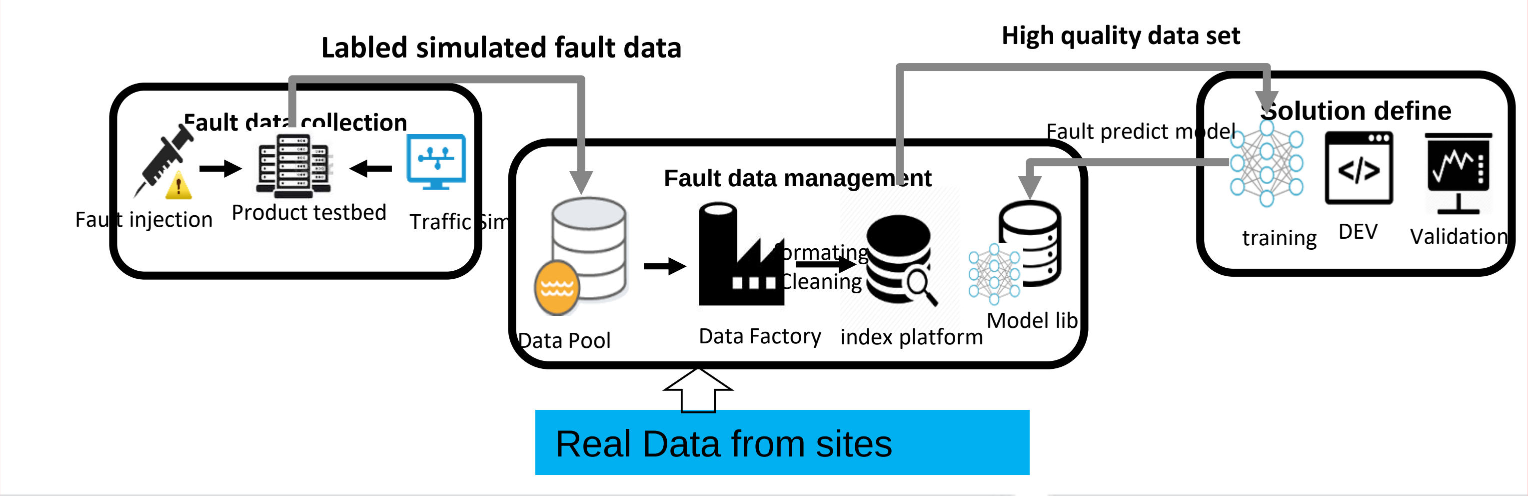
Data format is not uniform

- Data format is not uniform, each product data format up to 200+
- Data loss
- **Lack of standardization**
- Instrumentation incomplete

Less sample data - both simulated data and real data

- Simulated data combined with real network verification
  - Simulation of real network traffic tool
  - Fault Injection tool
  - NFV testbed and mirror env
- Successful case：
  - Slow disk detection
  - Wireless CPRI fault generation
  - Optical module failure
  - Memory leak failure
- The simulation of complex scenes remains to be improved





Few labeled data– semi supervised learning

- Idea: When label are difficult to automatically acquire, it is usually label them manually by a human oracle. Intuitively, randomly selecting instances to label experts is not the best strategy. Active Learning means ask Experts to lable the selected "best value "sample.

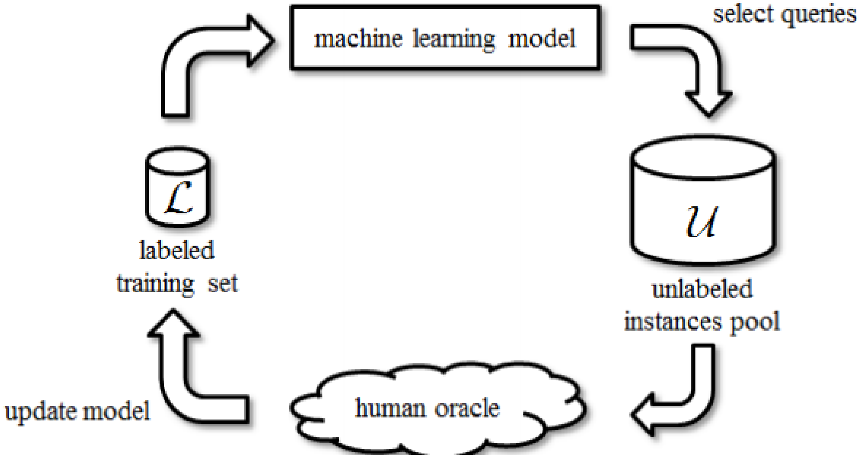


Fig. 1 active learning procedure

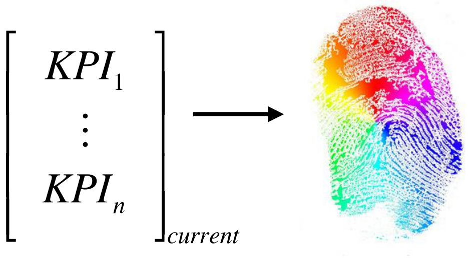
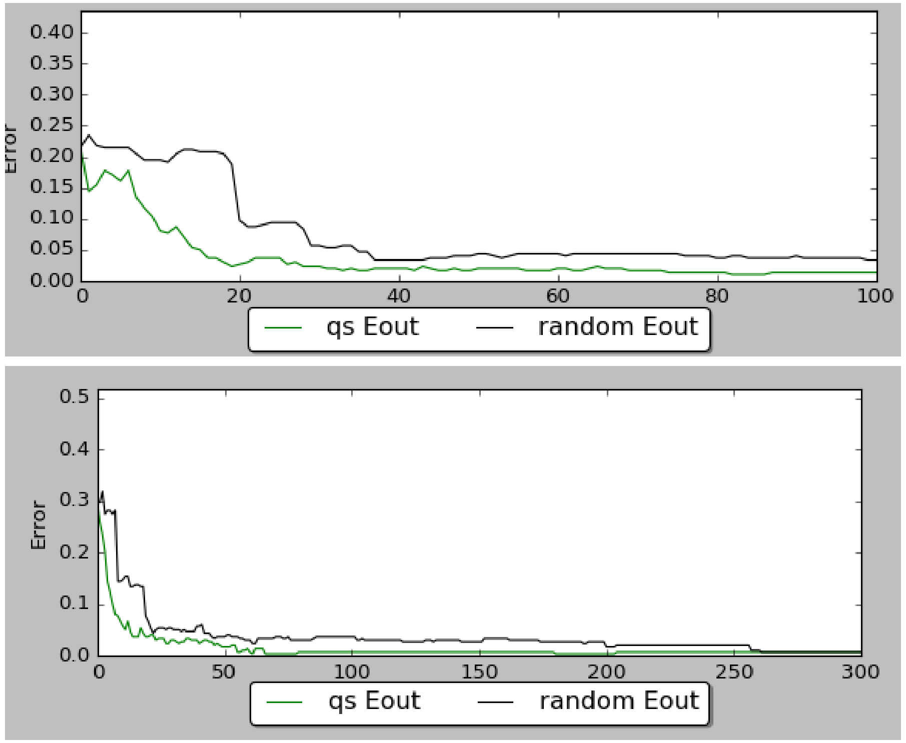


Fig. 2 Fingerprinting

In our experiments, we learned to automatically pick out the "most valuable" fault fingerprints and label them with domain experts. To achieve the same classifier accuracy, the number of samples required for active learning only needs one fifth or less of the traditional supervised learning.



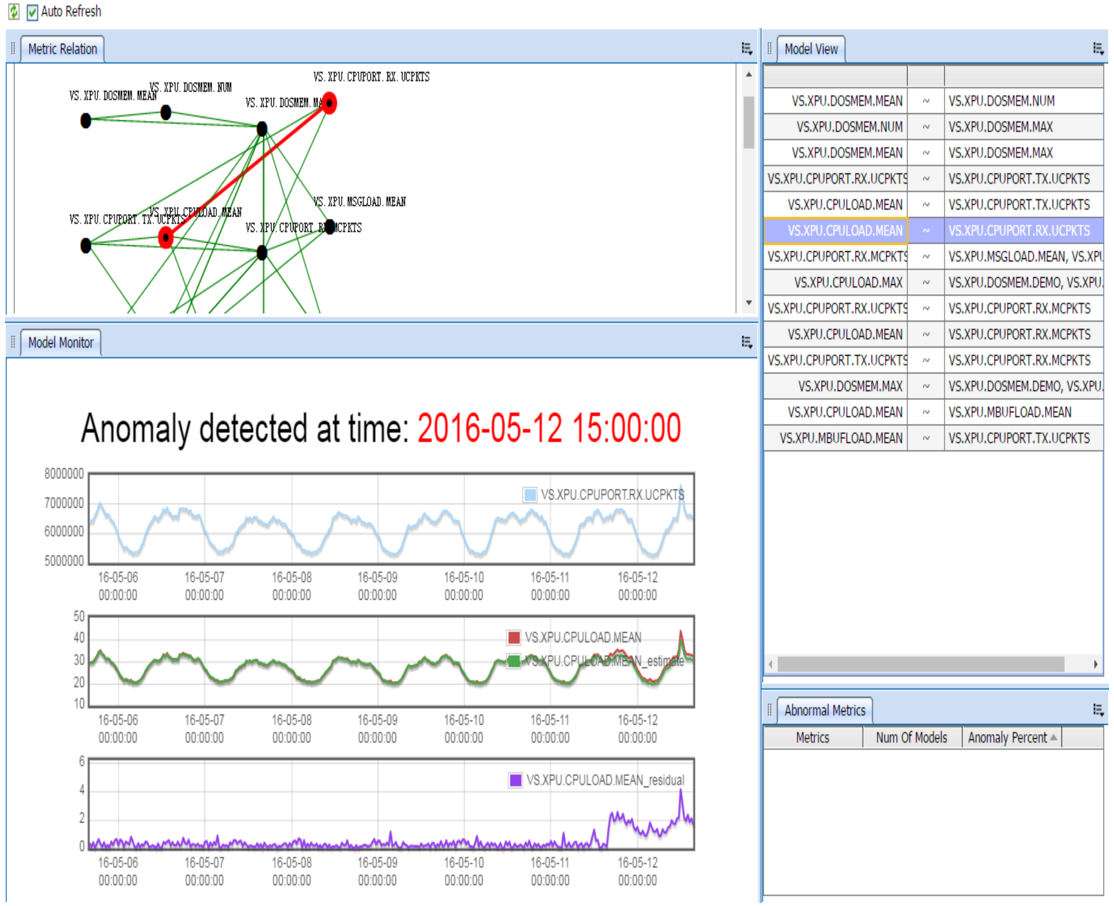
Green is active learning， Black is for traditional supervise ML,total samples: 900, intimal labeled 10

Result in our case:：

1. The more labeled samples, the lower the error rate.
2. no matter how many sample labels are selected, active learning is always better than traditional supervised learning
3. The more samples are selected, the lower the cost performance.
4. The initial marker sample is 10, and the sample size of active learning is about 20.

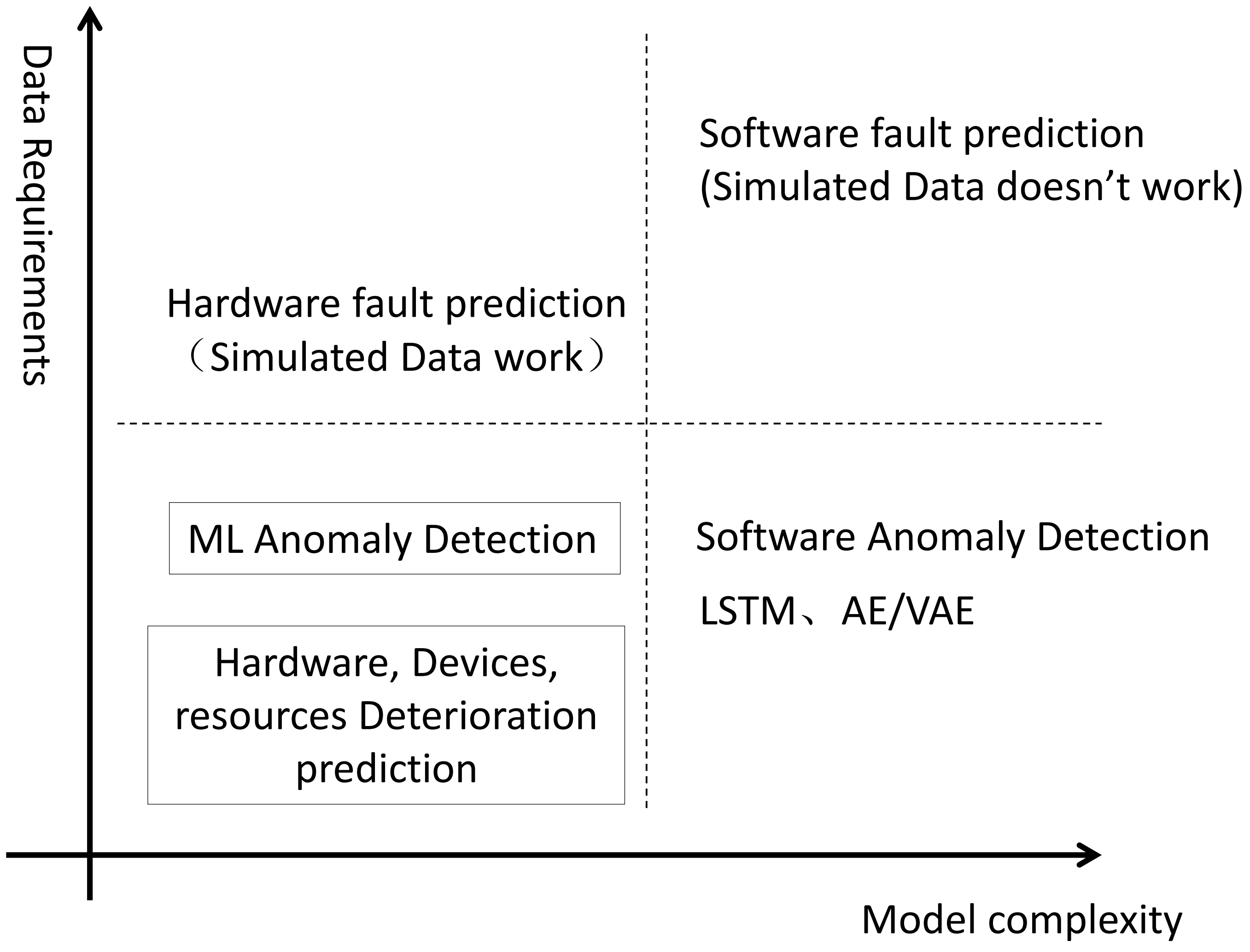
Algorithm: AI+ expert experience are equally important

- Feature extraction is an important part of traditional ML and also DL, and algorithm performance depends on human experience.
  - There is a saying in the industry of ML: if the feature is not done well, tuning the parameter will never stop.
- Fault data labeling needs expert feedback confirmation
  - Labeling heavily depends expert knowledge
  - EAI: It can significantly reduce the risk of "intelligent mis-operation" in complex tasks.
- Expert knowledge is a very important asset in the weak AI stage, which needs better management and solidification.
  - Rule based case can cover 80%, only 20% for AI based
  - Case intelligent search and knowledge map

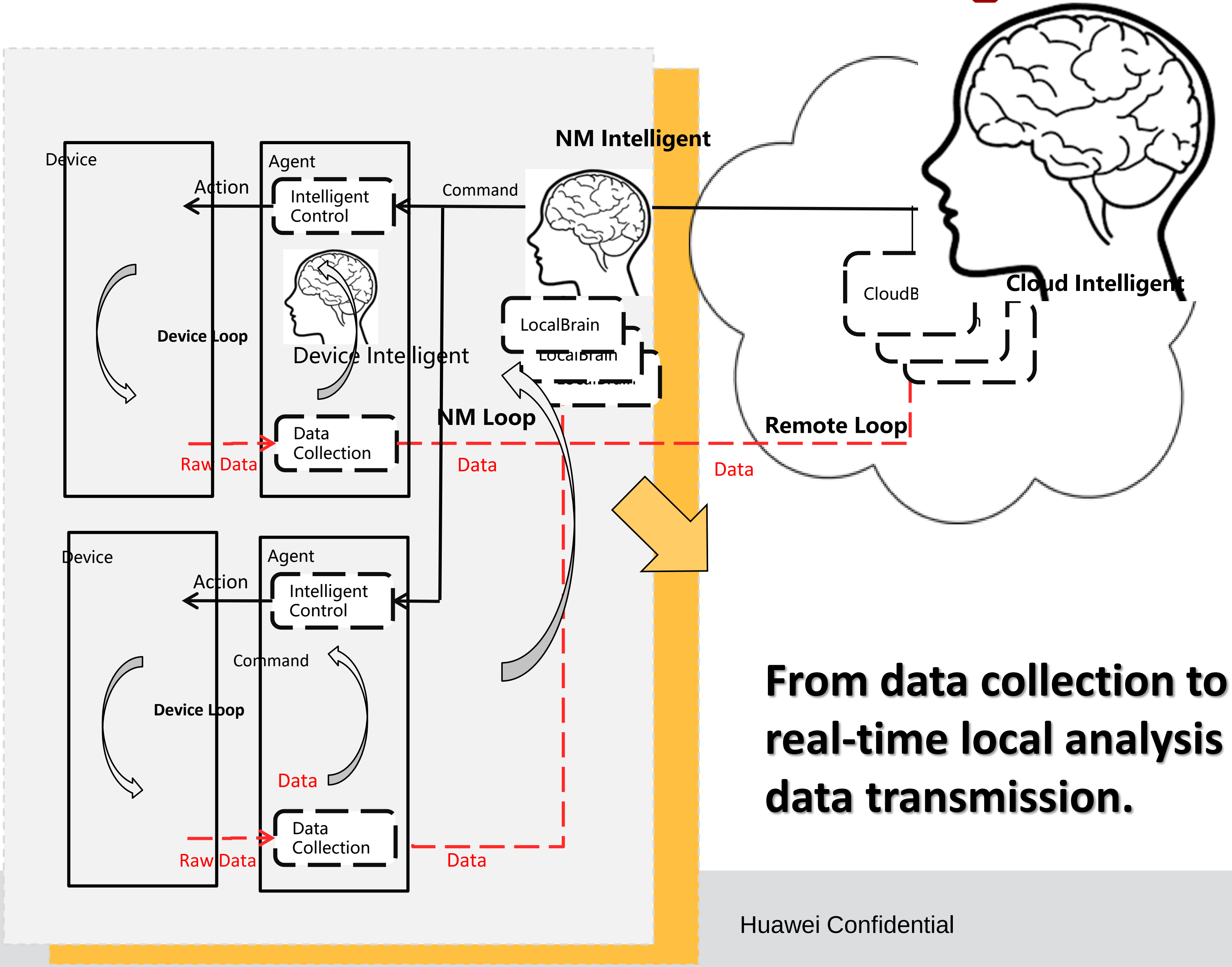


Relationship between model complexity and data

- Complex models are used to solve complex problems, and simple models solve simple problems
- For limited data, simple models may be better than complex models for complex problems
- Once data is enough, complex models can generate accurate results.



Architecture –Hierarchical intelligence



Hierarchical Intelligence /distributed ML：

- Intelligent Agent.
- Network Management Level Intelligence
- Cloud Intelligence

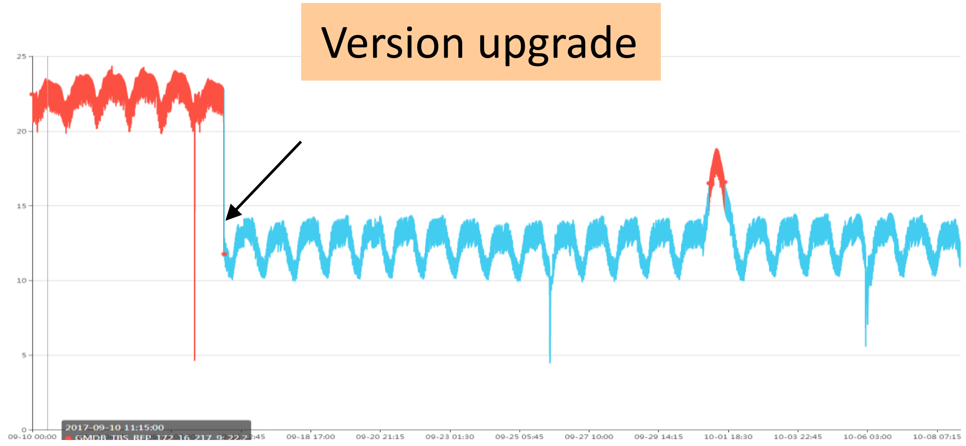
From data collection to abnormal perception, real-time local analysis of closed loop, reduce data transmission.

Challenge 1- algorithm model

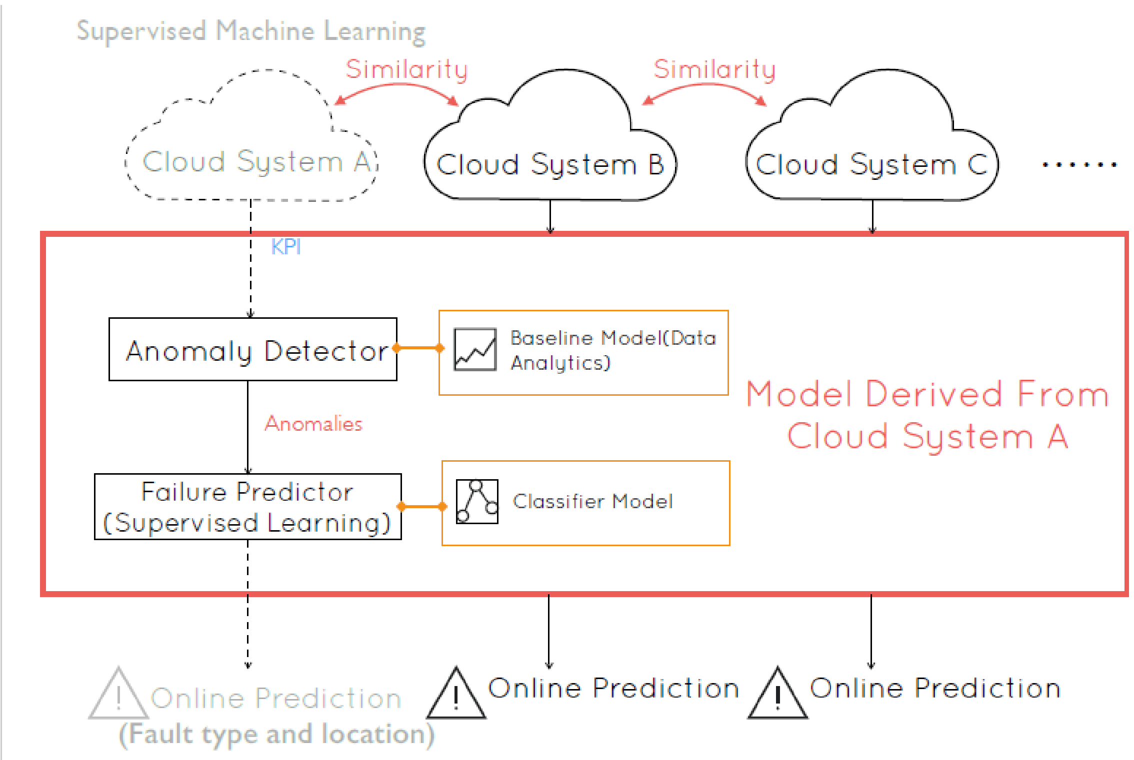
- Challenges of updating system state change models: for example, upgrades, operational promotions, resulting in changes in KPI sample distribution, and increased failure types (model evolvable)

- Requiring model reuse in a similar environment where sufficient data is difficult to obtain: model reuse, transfer learning needed

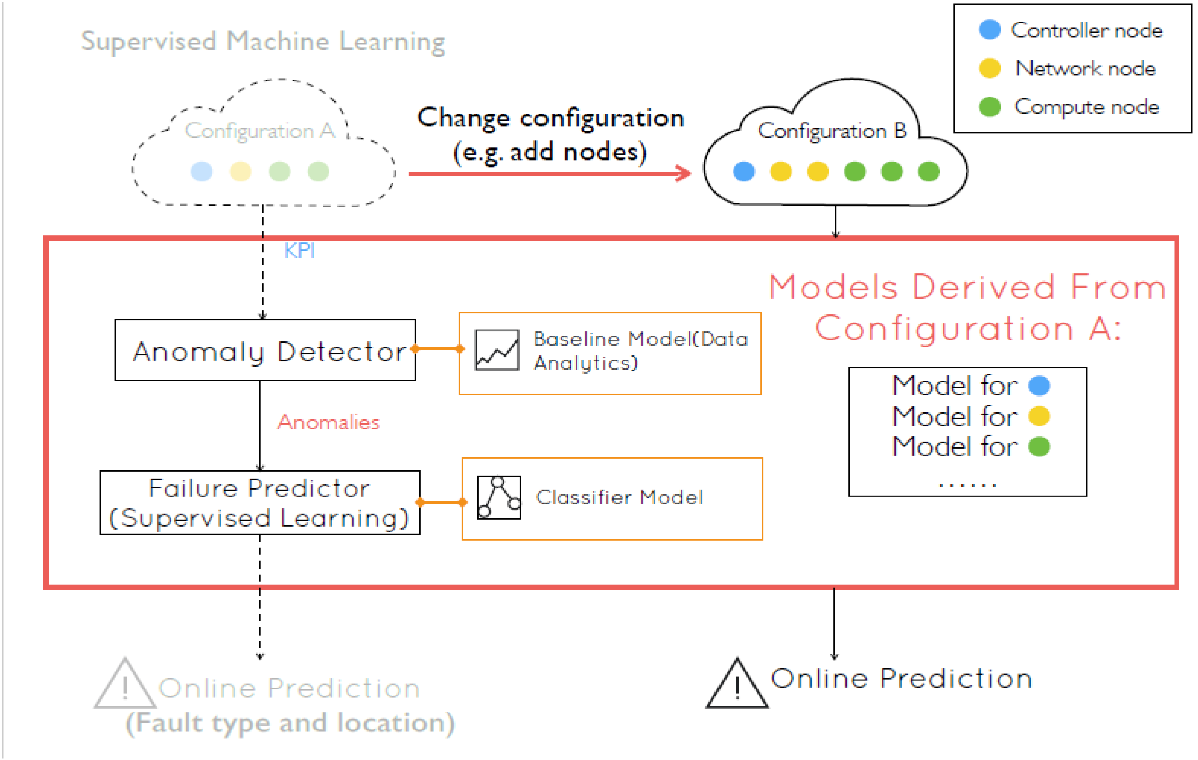
Google infrastructure upgrades will evolve into continuous upgrades of the network, incremental upgrades. New features and configurations are pushed into the product every week, so upgrades will be made every day, even multiple times a day.
Note: 2016 Sigcom articles and 2017blog from Googe



Inter and Intra system Prediction Models transfer challenges



Inter DC model transfer



Intra DC model transfer

Challenge 2- development mode need be changed

Challenges to the existing development process: online data closed-loop algorithm model tuning, update. (flexible) - to collect data from the existing network to form iterative feedback.

Requirements for development environment: we need to combine the existing network data to optimize the model.

Summary

- AI can assist to improve system availability in some cases but not all.
- AI based fault predict and prevention presents many challenges, we long way to go.
- Domain expertise is very important in define the solution
- Data suitability analysis before model development is a must
- Define models should based on what data you have. Simple models may have good results.

Thank you

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