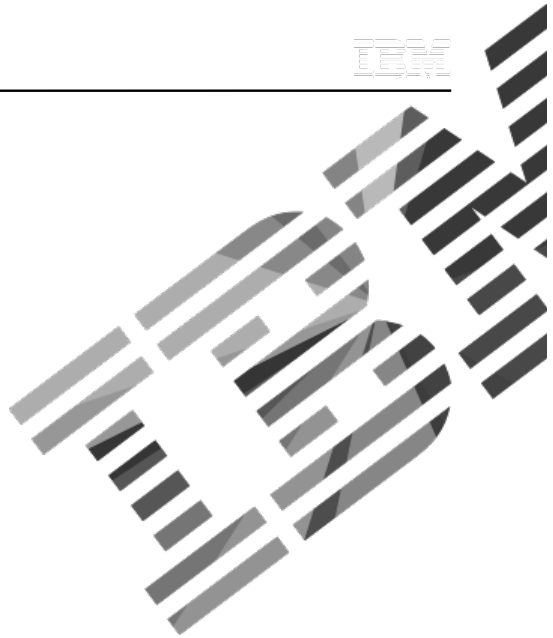
Neuromophic device for Automotive



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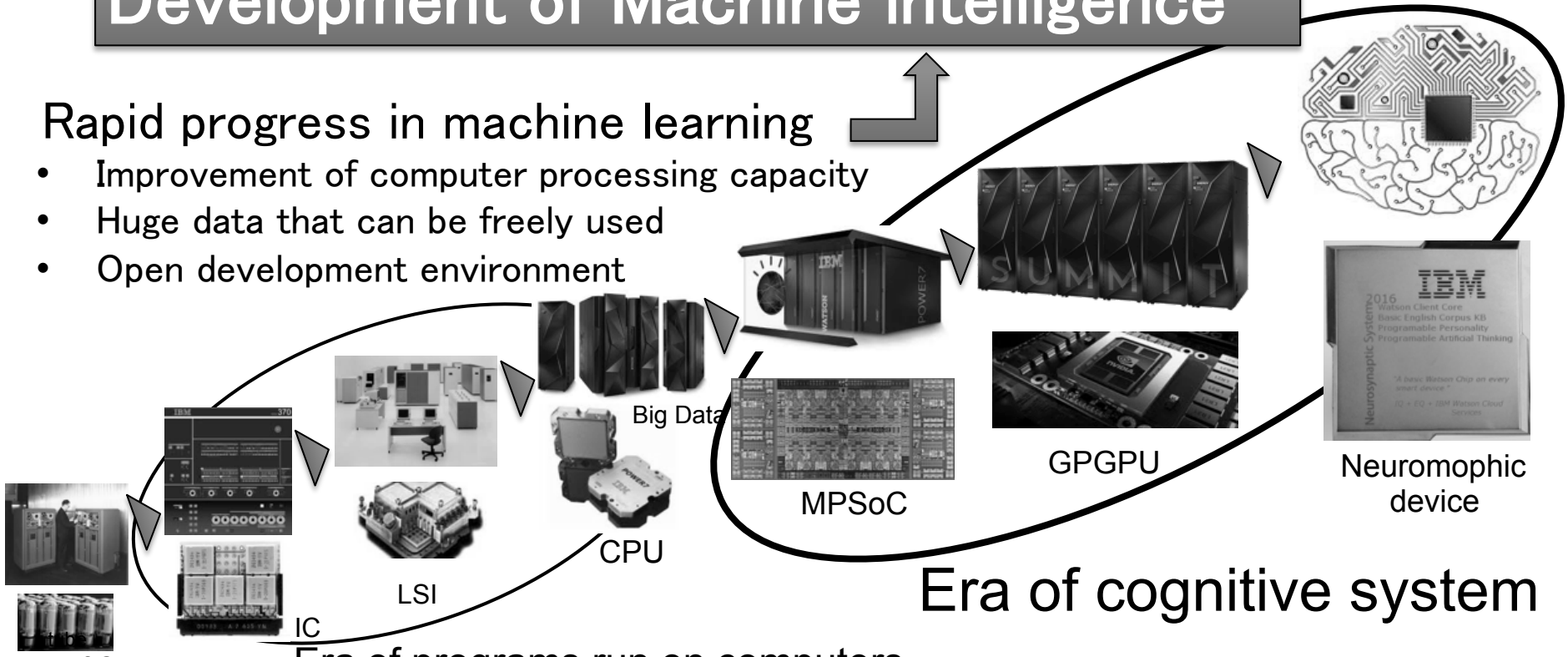
Transition of computing

Development of Machine intelligence

Rapid progress in machine learning

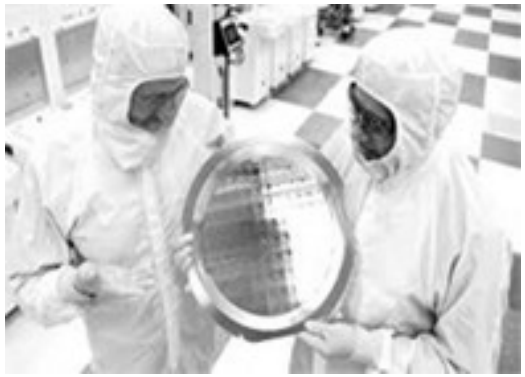
- Improvement of computer processing capacity
- Huge data that can be freely used
- Open development environment

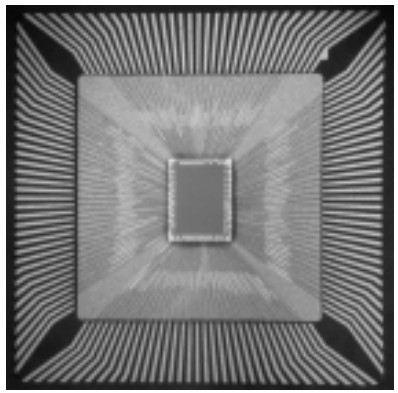


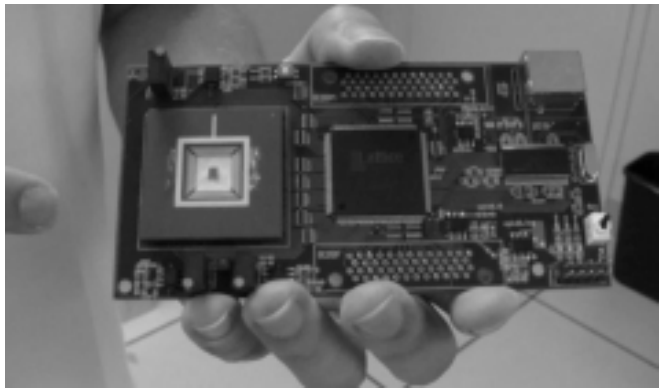
SyNAPSE Project – DARPA

- Development project of flexible and extensible system based on neural cell structure
- IBM acquired research funding from DARPA and developed a device imitating the neural cell information transmission mechanism

Neuromophic device







Background to the development of neuromorphic devices

In 2012, IBM executed a simulation of a neural network of 5 times the scale of the human brain (500billion neurons & 1exa synapse) using the world's fastest supercomputer.

Response time was 1,500 times slower than real time.

Real-time deep learning equivalent to one person
How to realize with a von Neumann type computer?

Huge computing capacity 6Exa FLOPS

- 480 Million processor cores
- 480 petabytes of memory
- 29, 491, 200 computer nodes

Huge equipment space

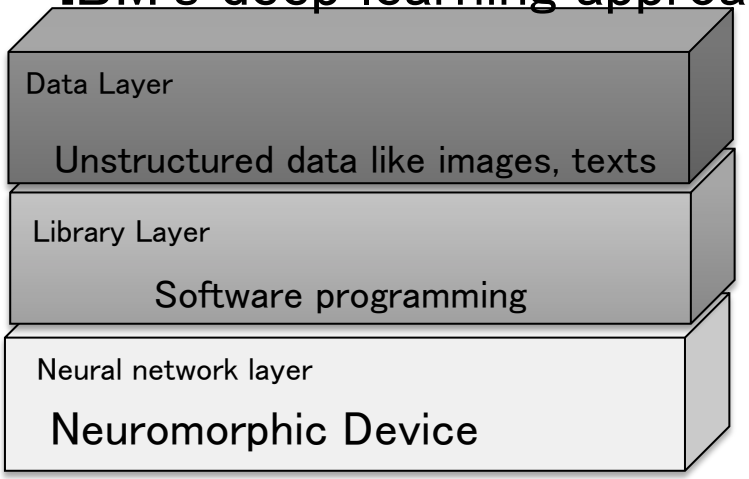
- Footprint area equivalent to 1.8 ballpark

Huge energy consumption

- Consumes electricity produced by two nuclear reactors

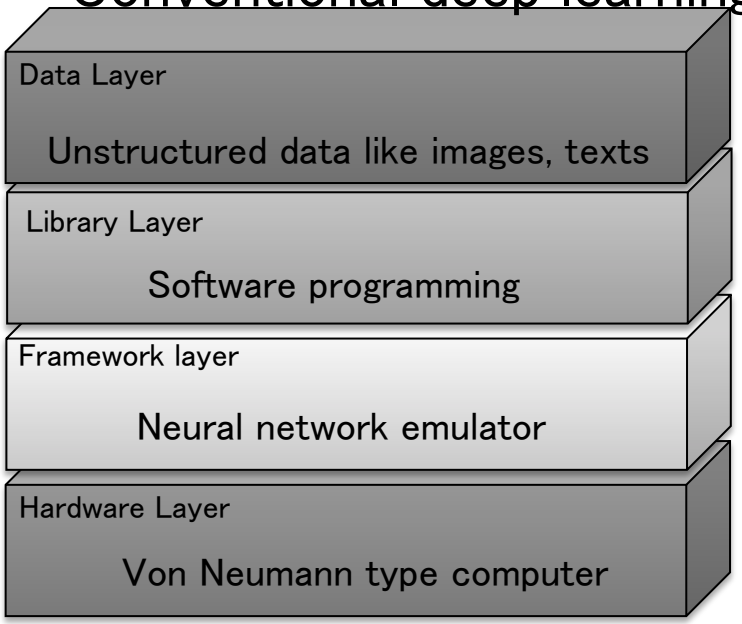
IBM's solution approach

IBM's deep learning approach



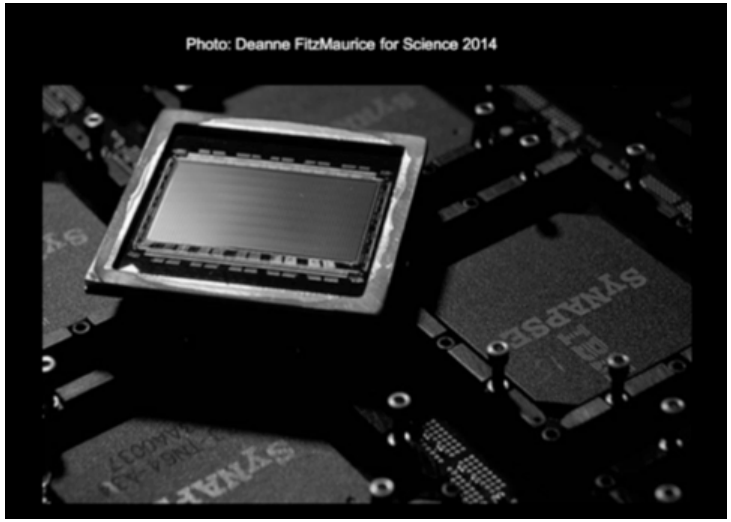
Developed a dedicated computer specialized for computation of neural network

Conventional deep learning



It is extremely inefficient to emulate a neural network on a conventional von Neumann computer

Computing Reimagined



- Number of transistors 5.4 billion
- Size 4.3 cm^2
- 4,096 cores
- A few million neurons
- Number of synapses 256 million
- On-chip memory 428 Mbits
- Event trigger 1 KHz
- Power consumption 72 mW

Realization of neural network by semiconductor

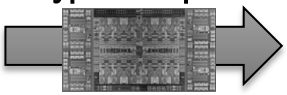
- Large scale parallel processing
- Independent of operation clock
- Data driven processing

Advantages when adopting neuromorphic devices in automobiles

Extremely few Energy consumption	High real-time performance	High defect tolerance And reliability
Independent of clock frequency & Event-driven processing	Multiple cameras in Real-time Object recognition	High resistance to variations in manufacturing process and random defects & Redundancy by large scale parallelization
Minimizing Active Power	**Real-Time Operation**	**Defect Tolerance**

Extremely few Energy consumption

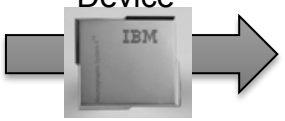
von Neumann type computer



Energy consumption

20mW/cm²

Nuromophic Device



Energy consumption

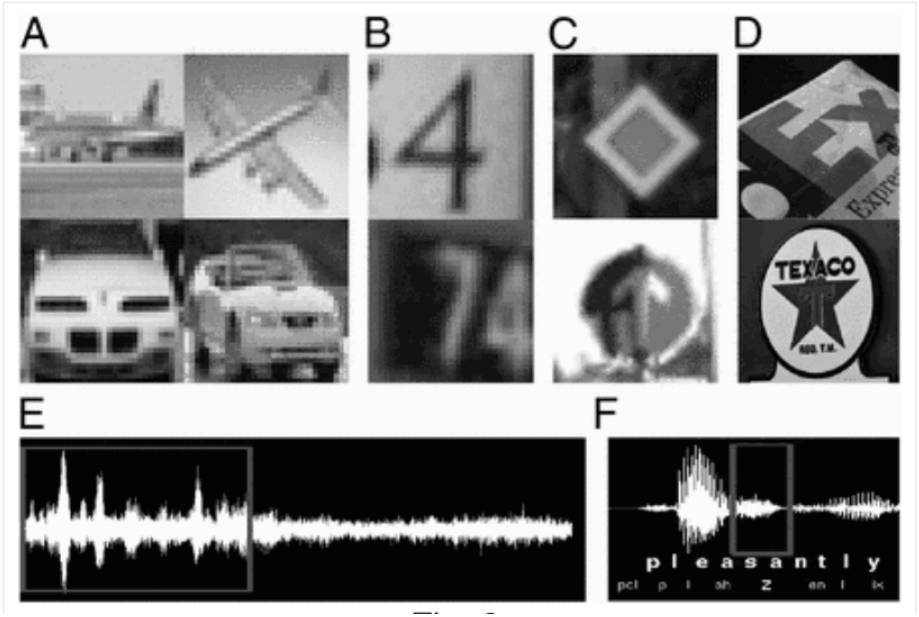
20mW/cm²

- 28nm process
- 4.3cm² chip size

1/2500 of conventional semiconductors

High real-time performance

IBM Advances Neuromorphic Computing for Deep Learning



Run deep learning program with only one chip
(CNN – Convolutional Neural Network)

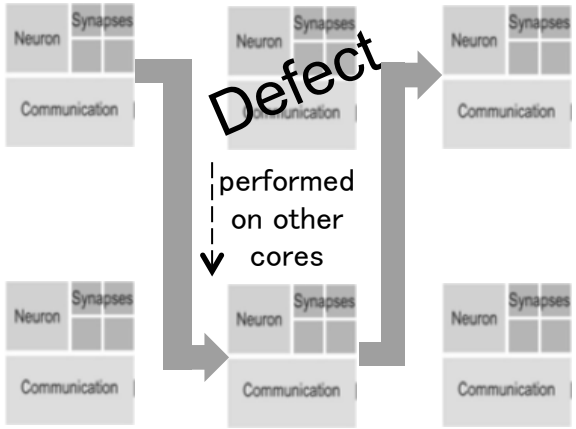
Ability to process data of nine cameras mounted in a car in real-time

Equivalent to image analysis of 450 to 975 HD sizes per second

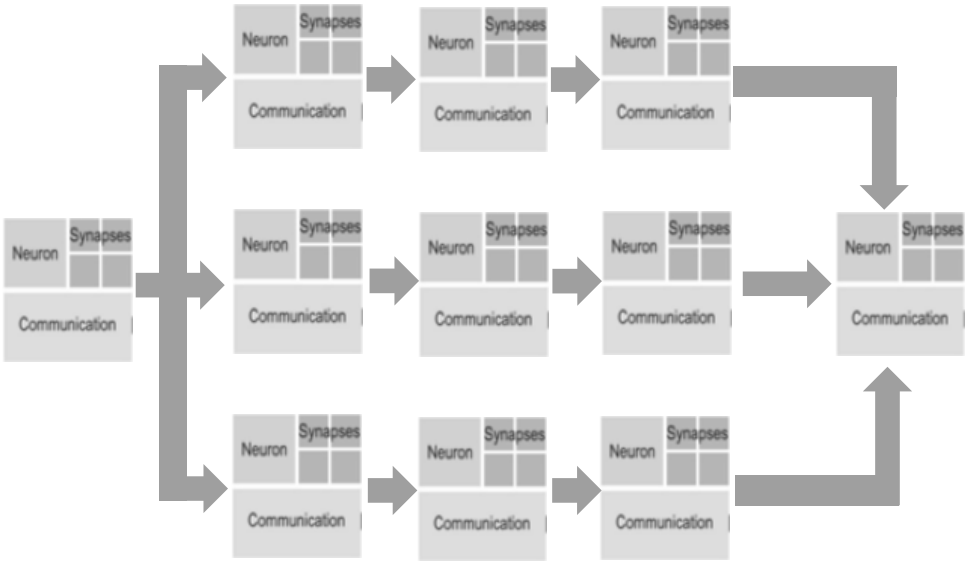
https://www.hpcwire.com/2016/09/29/ibm-advances-neuromorphic-computing-deep-learning/

High defect tolerance And reliability

- Defect tolerance – Treatment at the defective core is performed on other cores

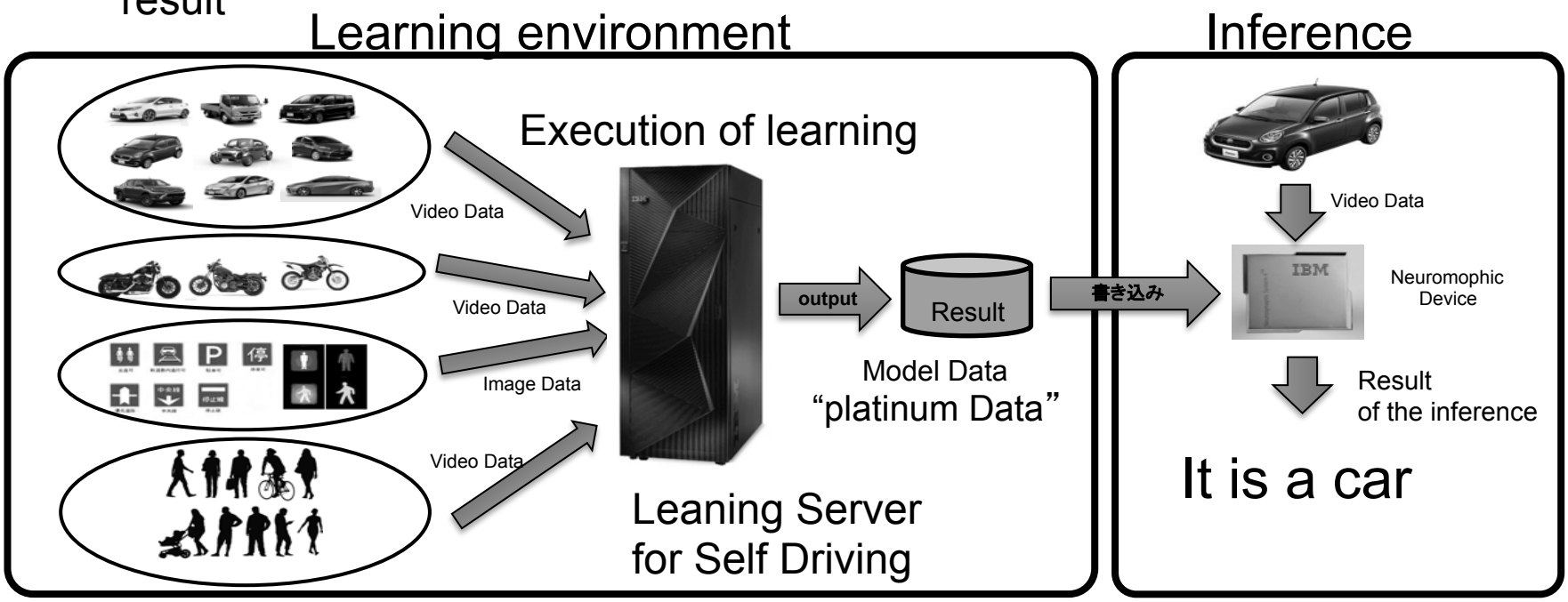


- Reliability – The majority voting system can be configured by programming



Self driving Car - learning and Inference in machine learning

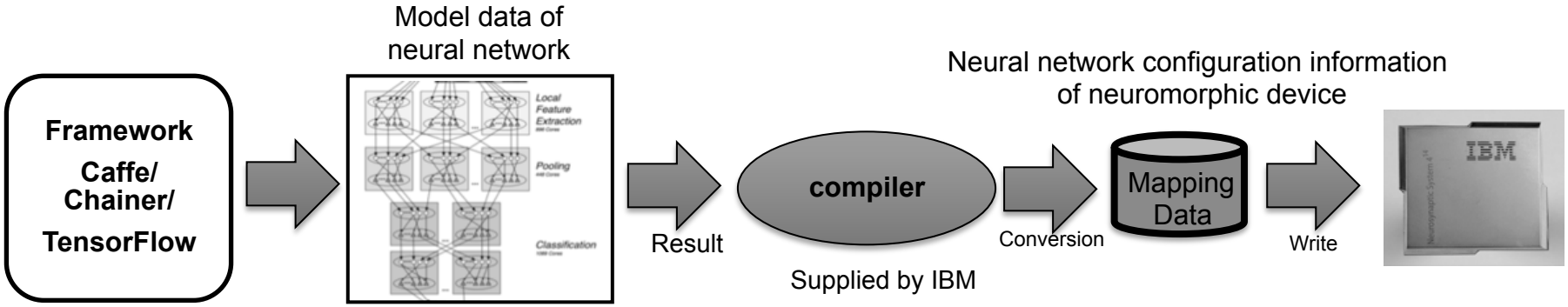
- Secure safety by restricting car learning
- The car executes the learning result and collects & transmits the traveling data
- Server for self-driving car learning from running data and distribution of learning result



Software environment for using neuromorphic device

Corresponds to several major machine learning development frameworks

Framework	Caffe	Chainer	TensorFlow
Developer	UC Berkeley	Preferred Networks inc.	Google
Language	Python,Matlab,C/C++	Python	C++, Ptthon
OS	Ubuntu,CentOS,OSX	any	Linux,OSX



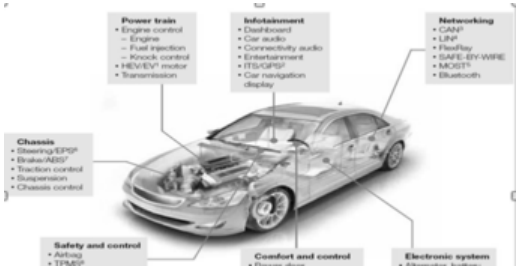
Application areas of neuromorphic devices in automobiles

Self-driving

Recognition of driving environment

Recognition and identification of external objects and environments can be realized in real time from sensor input

Vehicle motion control



Overall arbitration of integrated control

～Application to complex arbitration～

The overall priority can be instantaneously determined by inputting various states of the entire vehicle

Body system and passenger compartment

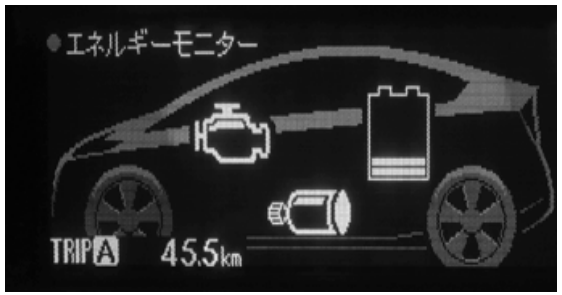
Realization of vehicle centric control suited to human senses

By inputting driving environment information and driver's state information to the car, it is possible to realize the calculation of the priority including the driver in real time

Next stage of Neuromophic devices for Automotive

Various running environments

Complex traffic



Tight energy constrai

Architecture

Neural network mapping technology making full use of hardware features Improvement

Performance

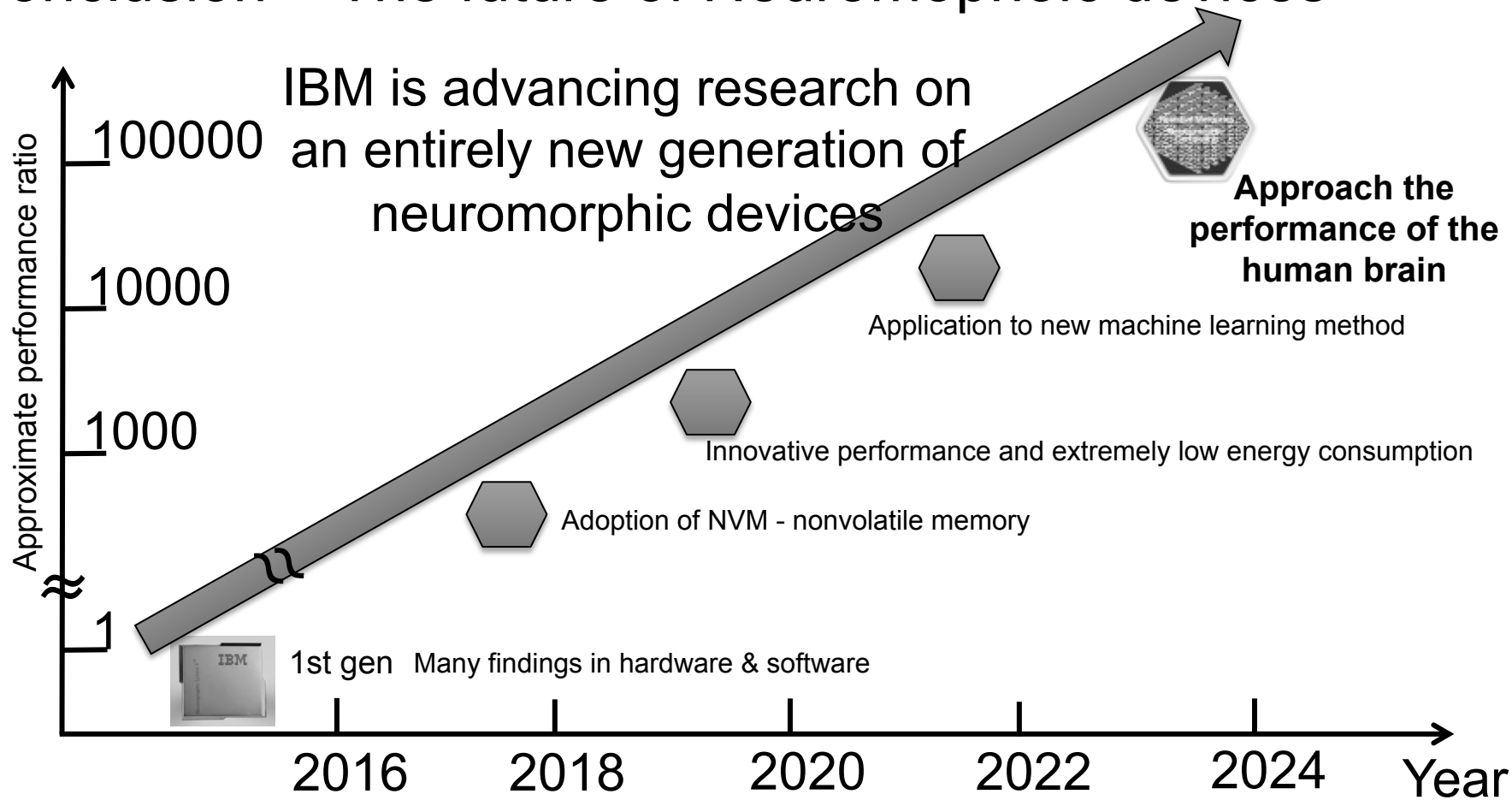
Ability to process a large number of objects in real time with simultaneous input of multiple cameras and multiple sensors

Energy consumption

Circuit design to minimize energy consumption

Further performance improvement is indispensable for application to automatic driving vehicles

Conclusion – The future of Neuromophoic devices



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