Technical Research on Advanced Computing

Hong Yang¹, Shurui Zhang², Xiong Guo³ and Mengliang Li⁴,*
¹,²,³,⁴ China Electronics Standardization Institute, China
*Corresponding author

Abstract—Due to the wide application of Internet of things, the real-time of data and the rapid development of AI, advance computing can provide technical support and guarantee. Firstly, this paper introduces the background, basic concept and development history, and classification of advanced computing. Secondly, the concepts, characteristics and key technologies of edge computing & fog computing, quantum computing, cognitive computing and ubiquitous computing are mainly introduced. Thirdly, the industrial application of advance computing are emphasized. Finally, the suggestion of advance computing is given.

Keywords—advanced computing; basic concepts; industrial application; suggestion

I. INTRODUCTION

A. Background

At present, the new technological revolution and industrial transformation are rising, and the global industrial technology system, development mode and competition pattern are facing major changes. The developed countries have introduced “re-industrialization” national strategies with advanced manufacturing as the core. As China puts forward the implementation of “China made 2025”, “one area one road” and “millions of industrial APP cultivation” strategy, the demand for computing technology is getting higher and higher, not only to be fast, but also to calculate well and steadily.

In the face of the continuous production of heterogeneous mass data, the traditional computing technology has gradually become tired. In recent years, international semiconductor technology has increasingly approached the physical limit in material and manufacturing technology. The development of traditional computing technology is faced with systemic difficulties. Advanced computing technology came into being to solve problems of different levels, different angles and different application scenes. At the same time, Application of Internet of Everything, Real-time and security of data and Artificial intelligence and deep learning require more advanced computation.

B. Concept and Development History of Advanced Computing

1) Concept

Advanced computing is to build the next generation of information infrastructure by using high-performance supercomputers and network systems, which makes the computers of dispersion in different geographical locations a huge virtual supercomputer and achieves the interconnection and sharing of network resources.

2) Development history of advanced computing

The history of advanced computing is relatively long and continues to develop [1]. According to the change of computing speed capability, the development history of advanced computing has gone through three major stages: device change, architecture change and computer principle change. Quantum computing, cloud computing, fog computing and edge computing began in 1988, 2006, 2011 and 2014 respectively.

II. EDGE COMPUTING & FOG COMPUTING

A. Edge Computing

1) Concepts

Edge computing is performed on an open platform at the network edge near things or data sources, integrating network, computing, storage, and application core capabilities and providing edge intelligent services. Edge computing open platform includes intelligent asset, intelligent gateway, intelligent system and intelligent service. Edge computing can be contrasted with centralized computing (for example, cloud...
computing), where the resources are centralized in large remote
data centers. However, it is important to note that edge
computing is complementary to centralized forms of computing
such as cloud computing and that in any given system, edge
computing is typically used in conjunction with centralized
forms of computing such as cloud computing [3].

2) Reference architecture

The reference architecture of edge computing includes
application domain, data domain, network domain and
equipment domain.

a) Application domain: Implement EC Industry
application and support EC service operation.

b) Data domain: Provide life cycle service, enable data
security & privacy, support distributed computing, and
scalability of ECN resource.

c) Network domain: Provide connection service for
interconnected systems, data aggregation and bearing; Satisfy
real-time requirement of service through real-time connection
and transmission.

d) Equipment domain: Support real-time intelligent
interconnection and intelligent application of field equipment;
Heterogeneous system architecture can meet the requirement
of real-time service and intelligent equipment; Lightweight
system architecture enable low power consumption.

3) Key technologies

The key technologies of edge computing include Software
Defined Connection, Time Sensitive Network and
Heterogeneous Computing.

a) Software defined connection

- Automated operation and maintenance: unified
  management of Connection, terminal, application;

- Unified policy of the network, data transport and
  security;

- Quick development, deployment and usage of
  application of machine vision, industrial control, etc.

b) Time sensitive network

- A set of standards under development by the TSN task
  group of the IEEE 802.1 working group;

- Built on the MAC/PHY layer of Ethernet, offers a low
  latency, time deterministic and high reliable way to
  send time-critical traffic over standard Ethernet
  infrastructures;

c) Heterogeneous computing

- Build a new system by using different types of
  instruction sets and architectural computing units

- Utilize the advantages of various technical units to
  meet the requirement of real-time service and high
  performance

B. Fog Computing

1) Concepts

A term created by Cisco that refers to extending cloud
computing to the edge of an enterprise's network. Also known
as Edge Computing or fogging, fog computing facilitates the
operation of compute, storage, and networking services
between end devices and cloud computing data centers. While
dge computing is typically referred to the location where
services are instantiated, fog computing implies distribution of
the communication, computation, and storage resources and
services on or close to devices and systems in the control of
end-users. Fog computing is a medium weight and intermediate
level of computing power. The main features of fog computing
include response feedback delay low, wide distribution and
high density, support local real-time processing, support the
movement of intelligent terminals and support wireless fast
access [4].

2) Reference architecture

The reference architecture of fog computing includes
performance, security, manageability, data analytics and
control, IT Business and cross fog applications.

e) Performance: Low latency is one of the driving
reasons to adopt fog architectures.

f) Security: End-to-end security is critical to the success
of all fog computing deployment scenarios.

g) Manageability: Managing all aspects of fog
deployments, which include RAS, DevOps, etc., is a critical
aspect across all layers of a fog computing hierarchy.

h) Data Analytics and Control: The ability for fog nodes
to be autonomous requires localized data analytics coupled
with control.

i) IT Business and Cross Fog Applications: In a multi-
vendor ecosystem applications need the ability to migrate and
properly operate at any level of a fog deployment’s hierarchy.

III. QUANTUM COMPUTING

A. Concepts and Characteristics

1) Concepts

Quantum computers are incredibly powerful machines that
take a new approach to processing information. Built on the
principles of quantum mechanics, they exploit complex and
fascinating laws of nature that are always there, but usually
remain hidden from view. By harnessing such natural behavior,
quantum computing can run new types of algorithms to process
information more holistically. They may one day lead to
revolutionary breakthroughs in materials and drug discovery,
the optimization of complex manmade systems, and artificial
intelligence [5].

Quantum computing is a new type of calculation mode that
follows the rules of quantum mechanics regulating quantum
information units. The general theoretical model of a quantum
computer is a universal Turing machine that is reinterpreted by
using the laws of quantum mechanics. It can solve the
problems that traditional computers can handle, and the
computational efficiency is greatly improved due to the
superposition of quantum mechanics. The research of quantum
computing can be divided into computational model, software and hardware, and algorithm research [6].

2) Characteristics

Quantum computing has four main features:

- The only way to solve it is to guess answers repeatedly and check them.
- The number of possible answers to check is the same as the number of inputs.
- Every possible answer takes the same amount of time to check.
- There are no clues about which answers might be better: generating possibilities randomly is just as good as checking them in some special order.

B. Development History

The history of quantum computing is mainly from the theoretical stage to the commercial outbreak stage. It has gone through three stages, namely, the concept, the medium-term development and the prospect of development.

FIGURE II. DEVELOPMENT HISTORY OF QUANTUM COMPUTING

a) Concepts stage: The concept of quantum computing was first proposed by P. Benioff at the Argang National Laboratory in the early 1980s.

b) Medium-term development: P. Shor, an applied mathematician at Baer laboratory, pointed out that quantum computing can break a large integer into the product of a qualitative factor with a shorter time in 1994.

c) Prospect of development: D-Wave, the Canadian quantum computing company, officially released the world’s first commercial quantum computer D-Wave One in May 11, 2011.

C. Related Technologies

Quantum computer technology includes quantum hardware, quantum coding and quantum software. Quantum hardware is the core challenge of quantum computing.
2) **Adaptive**: They may learn as information changes, and as goals and requirements evolve.

3) **Interactive**: They may interact easily with users so that those users can define their needs comfortably.

4) **Contextual**: They may understand, identify, and extract contextual elements such as meaning, syntax, time, location, appropriate domain, regulations, user’s profile, process, task and goal.

C. **Key Technologies**

- The top level technologies of cognitive computing is machine learning, natural language understanding and human-computer interaction.
- Big data technology, including the way to store, organize, manage and analyze.
- Computer architecture
- The bottom technologies of the cognitive computing needs atoms and nanoscale.

V. **UBQUITOUS COMPUTING**

A. **Definition and Features**

Ubiquitous computing is a concept in software engineering and computer science where computing is made to appear anytime and anywhere, which can occur using any device, in any location, and in any format. The features of ubiquitous computing include Universality, transparency, dynamic, adaptive, diversity and eternity [9].

B. **Key Technologies**

The key technologies of ubiquitous computing include technical support, digital home and rebounding technology.

1) **Technical support**: Mobile communication technology, Global network services and P2P peer-to-peer computing.

2) **Digital home**: The digital home connects the broadband network to the family through the home gateway, as well as handheld devices, personal PC or household appliances that connect to the network in wired or wireless ways, which can provide a seamless, interactive and ubiquitous computing environment. People can access the community service network anytime and anywhere.

3) **Rebounding technology**: The rebounding technology developed by IBM is a thin screen board, which can display personal home page and custom content. People can work or send messages anywhere with a small card.

VI. **INDUSTRIAL APPLICATIONS OF ADVANCED COMPUTING**

Advance computing can be widely used in aerospace, artificial intelligence, meteorological prediction and other industrial fields.

<table>
<thead>
<tr>
<th>NO.</th>
<th>CLASSIFICATION</th>
<th>INDUSTRIAL APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Edge computing</td>
<td>ladder network, smart grid, intelligent street lamp, intelligent building, intelligent IOV and intelligent agricultural machinery</td>
</tr>
<tr>
<td>2</td>
<td>Fog computing</td>
<td>Intelligent vehicle and traffic control, Video security and monitoring program, Intelligent city program</td>
</tr>
<tr>
<td>3</td>
<td>Quantum computing</td>
<td>Artificial intelligence, Machine learning, Weather forecast, Traffic congestion and Aerospace</td>
</tr>
<tr>
<td>4</td>
<td>Cognitive computing</td>
<td>self-driving cars, Automatic data input and automatic handwriting recognition and machine learning</td>
</tr>
<tr>
<td>5</td>
<td>Ubiquitous computing</td>
<td>Grid computing and Bluetooth</td>
</tr>
</tbody>
</table>

VII. **CONCLUSION**

Advanced computing is the key technical means to solve the major challenges of national economic construction, social development, scientific progress and national security, which is an important part of the national innovation system.

At present, the United States, Japan and the EU have invested a large amount of capital and manpower in the field of advanced computing technology to ensure the leadership of the technology. China has also issued relevant policies to support the development of advanced computing and industrial applications.

We propose to start the research on the topic of Standardization requirements analysis on advanced computing. Since Advanced Computing is useful for IoT, AI, Big data and other IT applications, it is necessary to set up a new working group on Advanced Computing.

**REFERENCES**