AI-Based Distributed Processing Automation in Digital Twin Network

draft-oh-nmrg-ai-adp-01

S-B. Oh (KSA), Y-G. Hong (Daejeon Univ.), J-S. Youn (DONG-EUI Univ),
HJ.Lee (ETRI), H-K Kahng (Korea Univ.)

nmrg Meeting@IETF 118 – Prague November 10. 2023

History and status

– 00 : draft-oh-nmrg-ai-adp-00 (July. 2023)
  - Title : Network management by automating distributed processing based on artificial intelligence

– 01 : draft-oh-nmrg-ai-adp-01 (Oct. 2023)
  - 1st presentation
  - Title : AI-Based Distributed Processing Automation in Digital Twin Network (To reflect the discussion result of IETF117 meeting)

Motivations

- Change of network complexity
  - High number of devices and data increate the network complexity
  - The possibility of malfunction or errors increases when network administrators/operators manage the network manually

- Adaptation to dynamically change network environment

- Maximizing the utilization of network resources
  - The increasing necessity of optimal resource allocation based on the characteristics of nodes providing network functions arises

Intention of this draft

- To efficiently adapt to the dynamically changing network environment
  - Find optimal configuration of systems using AI and DTN
  - Find optimal task distributed processing using AI and DTN
    - Requirements of task distributed processing
  - Propose automating distributed processing with DTN and AI

Conventional Task Distributed Processing Techniques and Problems

- Task Distributed Processing Technique
  - Distribute computational tasks among multiple nodes in a network
- Conventional techniques in task Distributed Processing
  - Load balancing
  - Parallel processing
  - Pipelining
- Challenges and problems in Task Distributed Processing
  - Prevention of Single network node overload
  - Prevention of overall process delays caused by bottleneck
  - Prevention of entire process disruption caused by network node failure

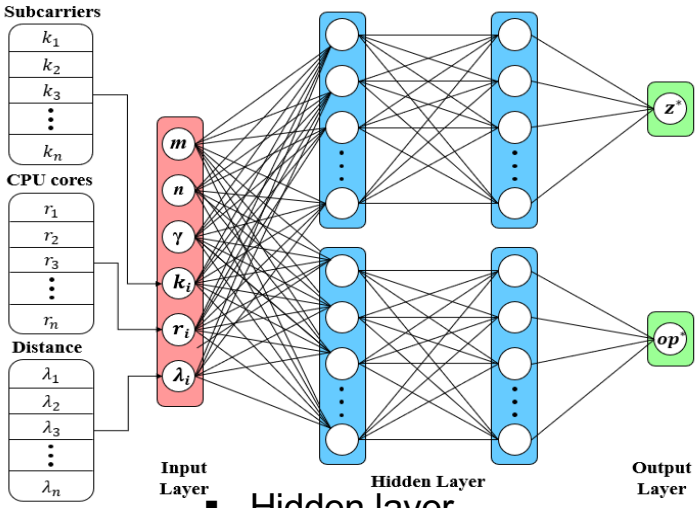
Requirements of Task Distributed Processing

- Scalability
  - The ability to add or remove nodes from the network and distribute tasks efficiently and effectively, without compromising performance or functionality.
- Fault tolerance
  - The ability to handle node failures and network outages without disrupting overall system performance or task completion.
- Load balancing
  - The ability to distribute tasks evenly across all nodes, ensuring that no single node becomes overwhelmed or underutilized.
- Task coordination
  - The ability to manage task dependencies and ensure that tasks are completed in the correct order and on time
- Resource management
  - The ability to manage system resources such as memory, storage, and processing power effectively, to optimize task completion and minimize delays or errors.
- Security
  - The ability to ensure the integrity and confidentiality of data and tasks and protect against unauthorized access or tampering.

Automating Distributed Processing with Digital Twin and AI

- DT and AI technology for Real-time Task Distribution:
  - The real-time updates from digital twin network enable continuous, optimal task distribution.
  - AI algorithms analyze network conditions and user demand in real-time.
  - Enables dynamic task distribution and processing based on current network conditions.
- Automatic Task Rerouting:
  - The system automatically reroutes tasks to less congested network areas.
  - Reduces delays and enhances overall performance.
- AI-driven Task Allocation:
  - AI algorithms, based on digital twin data, can automatically optimize network operations.
  - Tasks are distributed to nodes based on factors like processing power and available memory.
- Data that AI models can utilize within the digital twin network
  - Network data
  - Task and task characteristic data
  - Performance and resource data
  - Network configuration and device data

An example of AI system for Task Distributed Processing



- Input layer
  - Size of task(m)
  - Number of components(n)
  - Division resolution(γ)
  - Network status(k)
  - Available computing resources(r)
  - Distance(λ)
- Hidden layer
  - Two layers for each DNN model
  - Each hidden layer consists of 128 neurons
- Output layer
  - Optimal offloading(op^*)
  - Optimal partitioning(z^*)

Thanks!!

Questions & Comments