Agentic Network Architecture and Protocol for Supporting Agent Interconnection Communication and Multi-level Inference

draft-chuyi-nmrg-agentic-network-inference-00

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Motivation and Problem Statement

- More and more **agent interconnection scenarios** have emerged, bring the requirements of not only require **low latency and high bandwidth**, but also **efficient information exchange and cross-domain coordination and scheduling capabilities** in complex collaborative tasks.

- The interconnection of different agents also brings **emerging demand for inference**, large models and agents at **different levels need to cooperate** to complete tasks, resulting in a **complex intelligent agent interconnection network(like ACN for 6G)**.

- **Gateways and routers** serve as forwarding entries on the network road highways, responsible for building communication channels for the agents spread throughout the network, which requiring **function upgrades** to support the continuously evolving inference service in the future.

Motivation and Problem Statement

- **Agentic Gateway**
  - **Conception**
    Intelligent network element, capable of autonomously perceiving information and taking corresponding actions. It can perform all the functions of a gateway while integrating AI capabilities to execute planning, analysis, decision-making, and action execution for specific functions (such as intelligent route recommendation) or autonomous events.

    (Definition and specific functions of agent, how they interact with the outside world, and the requirements of multi-agent collaboration are mentioned at draft-chuyi-nmrg-ai-agent-network-02)
  - **Use case for example**
    In the industry factory, smart manufacturing robots collaborate on tasks, share multimodal data, and perform collaborative fault warning and handling through the gateway. At the same time, the gateway can issue certain control commands (such as regional collaborative control instructions) to enable coordinated equipment operation.
- **Agentic (IP) network**
  - **Conception**
    A novel network architecture composed of agents, network resource and computation resource for supporting agent interconnection technologies and functions, implementing agent interconnection protocols, and enables efficient collaboration among multiple agents as well as distributed multi-level inference.
  - **Use case for example**
    The Internet of Vehicles is composed of intelligent vehicles, road-side agents, and an cloud-central agent, they share information and collaborate with one another. Low-latency emergency decisions can be made at the vehicle end or road-side agent. The roadside agents are responsible for regional comprehensive information aggregation and inference,while the cloud-central agent is usualy equipped with full-scale models, handles complex tasks and cross-domain coordination.

Intelligent Forwarding and Routing

- Problem to solve
  - Due to the multiple connections of agents and the uncertainty of connection targets, gateways can be required to help users find collaborative agents.
  - Identical or similar requests tend to flow to the same agent or the same type of agents, making it necessary to construct high-speed forwarding paths for different types of agents from a global perspective.
  - Prevent all the traffic from flowing to the same agent and to implement intelligent distribution for load balancing.

- Solutions
  - Establish a routing and forwarding protocol that matches appropriate agent service characteristics and requirements, helping agent routing decisions and addressing.
  - Perform dynamic addressing by considering agent's max-connections, application intent, real-time load, and link quality.
  - Reinforcement learning algorithms can be used to enhance the selection of optimal paths.

Intent and Network Environment Perception

➢Problem to solve

- Perceive the intent of user service forwarding to select the agents for completing tasks.
- Perceive the environmental status of agents, such as their status (online/offline), load, link quality, and computational capacity, to determine the next hop or target
- Perceive and record the impact of each path planning and selection on network performance (e.g., whether traffic to the target agent is alleviated, network congestion status, etc.), enabling the self-learning and self-optimization of the agentic gateway

➢Solutions

- The above information serves as standard information fields collected by devices, and agents can subscribe to interfaces to access and utilize this information.

Protocol Compatibility and Conversion

- Problem to solve
  - Devices with different protocols converge and communicate within the gateway, requiring protocol compatibility and conversion.
  - Perceived data from different systems must be "translated" into a unified language before it can be used for next analysis.

- Solutions
  - Set up protocol policy templates, enabling the gateway to automatically identify protocols.
  - Support multimodal transformation, and enable the transformation of context-transmitted content (such as the conversion of MCP results).

Support Multi-level Inference

- Problem to solve

  After the establishment of tasks, there will have a significant demand for inference, which is addressed by leveraging edge or remote inference capabilities:

  - Edge gateways or edge nodes identify and determine to require edge inference versus central inference
  - Agents deployed on edge gateways recognize inference requests, cache popular content, and enable the reuse of identical requests within the domain locally, reducing the number of inference calls to large models.

- Solutions
  - Classify user inference services and carry this information during routing, enabling identification by the gateway.

Information Management and Control

- Problem to solve
  - As a new feature, agents need to be integrated into existing communication networks, requiring modeling and the establishment of usage patterns for their integration, including necessary management mechanisms.
  - The network must centrally manage intelligent network elements such as agentic routers and gateways, maintain path information, and store rules.
  - Multi-agent collaboration to complete tasks requires coordination between the central and the edge. The central is responsible for global optimization and information coordination, the edge handles local optimization, information synchronization, and task distribution, while the end is responsible for specific execution.
- Solutions
  - Allow agentic gateways to continuously perceive and discover newly online agents, and report this information to higher-level management. New agents can register directly through the edge gateway upon network access.
  - Manage intra-domain agent addresses, synchronize and maintain teaming information, and ensure consistency between routing identifiers and networking relationships.
  - Acting as an execution entity for upper-layer orchestration and management, it possesses information reporting capabilities, executes management instructions from higher layers, and implements cross-domain access control. The reported information is aggregated at the management layer, where it is uniformly invoked and analyzed by the orchestration layer.

Equipment-level Autonomous Operation and Maintenance

➢Problem to solve

- Primarily realizing no-human operation and autonomous event handling.
- Collaborate with other O&M agents to perform cross-domain comprehensive diagnosis and provide necessary data.

➢Solutions

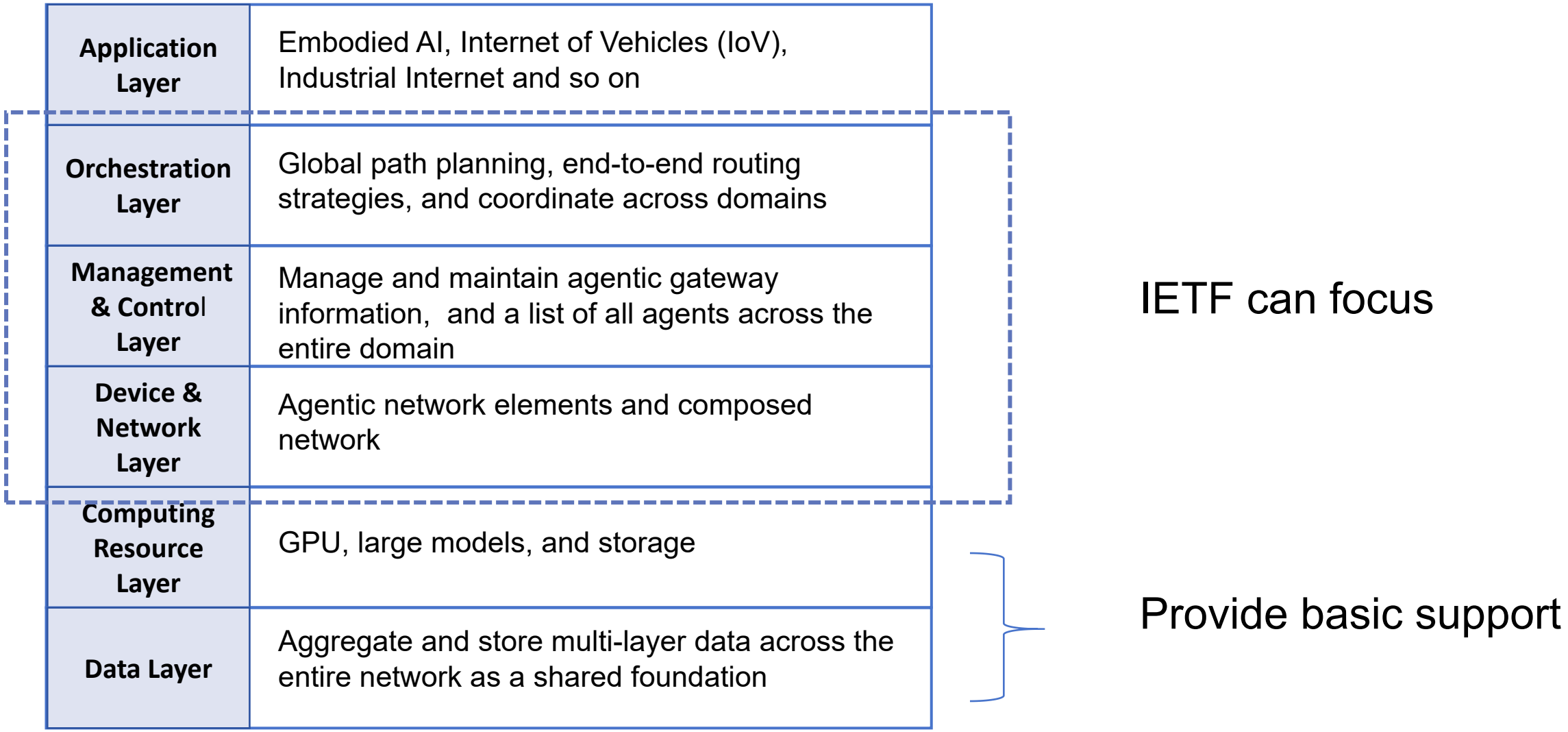
- Make judgments based on data collected by network elements, using the implications of thresholds (e.g., whether performance thresholds are exceeded). This requires standardized data rules and policies.

More details can be found at draft-chuyi-nmrg-ai-agent-network-02

Safety

- Leverage AI-driven situational awareness and anomaly detection to identify and counter covert attacks (L7)
- User and content access control (L7)
- Data access control (L7)
- Full lifecycle auditing (L4)
- Network security status monitoring (L3)
- IP address access control (L3)

Architecture of Agentic Network for Multi-level Inference



Next Step

- Current Status
  - Draft-00 has been submitted to NMRG, mainly covers the viewpoints shown today

- Future Work
  - Refine the requirements for agentic network elements and networks
  - Map the above requirements to each layer, identifying the specific impacts and modifications to the protocols at each layer of IP network
  - Further research on the architecture of agentic network

Welcome comments and co-work for this topic!

Thanks!