

Research on the Construction and Operating Mechanisms of the Communication Hypernetwork System under the Strategy of Computing – Power Coordination

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Abstract

Computing–power coordination is becoming a new normal for digital-era infrastructure and is profoundly changing the underlying connectivity of communication systems. Existing studies mostly follow the linear logic of “power supply–computing support–content distribution,” making it difficult to reveal the deeper structural changes in communication systems under computing–power coordination. This paper adopts a hypernetwork perspective, conceptualizing the communication system as a heterogeneous hypernetwork of computing, power, communication, user, and institutional nodes. The study identifies four mutually nested and self-locking dilemmas: singularized node identities, sparse heterogeneous connections, centralized decision-making, and lagging institutional adaptation. This paper proposes a three-stage transition path from an “initial stage” to a “deep hypernetwork,” with core mechanisms including the multiplication of node identities, heterogeneous direct connections and short feedback loops, and distributed decision-making and local self-organization. The essence of hypernetwork construction is a structural transformation of communication power from “vertical echelon distribution” to “networked fluid distribution.” This study provides a new analytical framework for understanding the structural transformation of communication systems under computing–power coordination.

Keywords

Hypernetwork; Computing–Power Coordination; Media Infrastructure; Construction of Communication Systems; Systemic Transformation of Mainstream Media

1. Re-examining Media Infrastructure: The Communication System as a Hypernetwork

1.1. The Evolution of Media Infrastructure: From “Pipeline” to

“Computing Foundation”

Structural transformations of communication systems are rooted in changes in media infrastructure. Understanding the current hypernetwork transformation requires tracing media infrastructure’s evolution from passive supporter to active constructor.

In traditional mass communication, media infrastructure comprised printing equipment, broadcasting towers, and cable networks. These facilities served mainly as content-distribution “pipelines” and material carriers, not as constructors of communication order. The power structure of the communication system was usually determined by the content-production end, while infrastructure remained in a “backstage” position and became perceptible only when failures occurred. Shu Kairong points out that this “quasi-transparency” kept infrastructure at the margins of communication research for a long time.

The Internet brought the first fundamental shift: submarine cables, base stations, and data centers became the physical foundation of global information communication, and communication power began shifting from content producers to platforms. Shi Anbin and Zhu Hongyu also emphasize the site construction and resource allocation of communication infrastructure. During this period, research on media infrastructure began to receive widespread attention, and the agency of “things” was rediscovered. Infrastructure was no longer a passive material carrier but an active node that connected different actors and jointly constructed communication networks with users.

However, the truly structural transformation occurred in the age of artificial intelligence. As large-model training, AIGC content generation, real-time inference, and other scenarios have been applied at scale, demand for computing power has grown exponentially, and computing facilities have begun to become a core component of media infrastructure. Chen Changfeng and Yuan Yuqing point out that artificial intelligence is becoming communication infrastructure. Media infrastructure’s foundation has shifted from connectivity to computing-power supply, now central to platform competitiveness.

Media infrastructure is thus shifting from “connectivity pipeline” to “computing foundation.” Computing power is no longer mere technical support but a key variable shaping the communication system, and computing-power coordination—the national path to improving computing efficiency and layout—becomes its material foundation and core driver.

1.2. Computing-Power Coordination: The Material Foundation of the Hypernetwork Communication System

The concept of computing-power coordination emerged under the dual pressures of exponential growth in computing demand and structural transformation of energy supply in the artificial intelligence era. With the large-scale application of

large-model training, AIGC content generation, real-time inference, and other scenarios, demand for computing power is rising at an unprecedented rate. Driven by national strategies such as the “Eastern Data, Western Computing” project, China has formed an “8+10+3” computing spatial layout focused on 8 national computing hubs, 10 national computing clusters, and 3 computing–power coordination development regions. It is against this background that coordination between computing power and electric power has been elevated to the national strategic level.

In June 2026, Li Chao, deputy director of the Policy Research Office of the National Development and Reform Commission, explicitly stated that the computing network, the new-type power grid, and the next-generation communication network together constitute important foundations of the intelligent economy and intelligent society. Promoting the collaborative integration of these major infrastructure networks can optimize supply–demand matching, achieve systemic optimization, and improve overall efficiency. She also noted that current coordination between the computing network and the new-type power grid still faces many bottlenecks in planning, construction, pricing mechanisms, and other areas.

At the infrastructure level, computing–power coordination entails deep coupling between the computing network and the power grid. Their relationship is no longer a one-way supply of power to computing but a two-way, mutually conditioning one. The new-type power grid provides low-cost, sustainable green electricity, reducing AI training and inference costs; conversely, computing clusters provide ideal settings for renewable-energy consumption. The high and uninterrupted loads of AI data centers can absorb excess wind and solar power in western China, and computing parks can act as virtual power plants for peak regulation. This two-way relationship means that computing nodes and power nodes are evolving from an upstream–downstream relationship into a symbiotic one.

This trend is taking shape: key projects have been intensively implemented in Inner Mongolia and Gansu; computing parks are being explored as virtual power plants for peak regulation; and 145 trunk optical cables now connect national computing hubs, with delays between the 8 major hubs below 20 ms. Such low-latency, high-bandwidth connectivity enables real-time sensing and control among power, computing, and communication nodes.

Computing–power coordination thus produces composite nodes: a computing park is simultaneously a computing, power, and communication node; a user terminal is simultaneously a communication, computing, and potential flexible-load node; and through task scheduling and sharing, terminals can serve as distributed computing nodes. This multiplication of node identities materializes hypernetworks’ “multidimensional embedding.”

1.3. The Composition and Core Characteristics of the Hypernetwork

Based on the above analysis, this paper introduces the “hypernetwork” perspective to understand the communication system under computing–power coordination. The concept of the hypernetwork was introduced into Chinese academia by Wang Zhongtuo in 2008. It refers to “a network above and beyond existing networks,” or “a network of networks,” and is suitable for analyzing complex systems in which multiple types of networks—such as logistics, information, and capital—are intertwined.

In this paper, the communication system under computing–power coordination is understood as a hypernetwork composed of heterogeneous nodes and heterogeneous edges. Node types include computing nodes, power nodes, communication nodes, user nodes, and institutional nodes. Edge types include energy flows, data flows, attention flows, control flows, and value flows. Based on this definition, this paper proposes three core characteristics of the hypernetwork:

1) Non-hierarchy

In a hypernetwork, any node can directly couple with any other type; no fixed vertical order exists, and centers emerge dynamically. In the communication system examined here, non-hierarchy means user terminals can directly perceive electricity prices and decide whether to perform local computing without platform or computing-center mediation, while edge nodes can coordinate with adjacent nodes without central instructions.

2) Multidimensional embedding

The same physical entity can simultaneously assume multiple node functions. For example, an edge data center is simultaneously a computing node, a communication node, and a power node; a user terminal is simultaneously a communication node, a computing node, and a potential energy-storage node.

3) Adaptive evolution

Hypernetworks achieve distributed self-regulation through redundant connections and short feedback loops. In a densely heterogeneous network, when one path is blocked, the system can automatically switch to an alternative path, and local nodes can make autonomous decisions based on perceived state information without waiting for central instructions. Redundant connections mean that multiple heterogeneous paths are available for any two functional goals. Short feedback loops mean that feedback does not need to be reported and issued level by level; heterogeneous nodes can directly form closed loops. This structure gives the system greater resilience and flexibility.

2. Hypernetwork Diagnosis of the Current Communication System: Structural Dilemmas and Misalignments

2.1. Singularized Node Identities: Separation and Ossification of Functional Positioning

In an ideal hypernetwork, the same physical entity can simultaneously assume

multiple node functions, achieving “multidimensional embedding.” However, most entities in the current communication system still follow independent functional positioning logics, and node identities exhibit a marked singularity.

This singularity is first manifested in the separation of computing nodes and communication nodes. Traditionally, data centers and edge nodes are computing infrastructure, while media platforms and content distribution networks are communication infrastructure. They differ in ownership, management, and operational logic. Even as computing–power coordination accelerates, most computing nodes have not acquired the functional identity of communication nodes and are unable to actively participate in content distribution and communication scheduling. Conversely, most communication nodes have not acquired the functional identity of computing nodes and cannot flexibly invoke or contribute computing resources according to the real-time needs of communication tasks.

Second, the functional positioning of user terminals is likewise singular. In the current communication system, smartphones, personal computers, and other terminal devices are mainly positioned as content-receiving ends, and users are regarded as passive audiences at the end of the communication chain. The distributed computing potential contained in their terminal devices remains largely unactivated. Existing research points out that core data and computing power are monopolized by a small number of platforms, forming a “center–periphery” pattern. Furthermore, the dilemma of communication infrastructure being “pipelineized” also reflects the ossification of node identities. Under the impact of distributed Internet communication networks, the exclusive definition power of traditional mainstream media as information hubs has been dissolved. If mainstream media participate in competition only as single communication nodes, their room for bargaining with commercial platforms will continue to narrow. Only when communication nodes simultaneously acquire multiple identities—such as computing nodes and even power nodes—can they establish irreplaceability in the new hypernetwork landscape.

2.2. Sparse Heterogeneous Connections: Absence of Cross-System Direct Channels

The second core characteristic of hypernetworks is the high-density direct connection between heterogeneous nodes. In the current communication system, connections among power nodes, computing nodes, and communication nodes remain indirect, sparse, and characterized by long feedback.

The decentralization of communication power coexists with lagging connection mechanisms. The Internet has already built a distributed communication network, and information flows have shifted from one-way controllability to multi-point concurrency and viral communication. The agenda-setting effectiveness of traditional mainstream media has begun to decline. However, power nodes and

computing nodes still mostly interact indirectly through centralized scheduling intermediaries and lack point-to-point real-time sensing channels. There is almost no direct connection between communication nodes and power nodes; the energy-consumption response of communication tasks can only be realized indirectly through computing nodes. Fang Xingdong et al. also point out that there is a structural misalignment between the positioning of mainstream media and the current dominant communication paradigm.

This lag creates practical dilemmas. First, computing scheduling platforms cannot obtain real-time electricity signals and load states from power nodes, leaving decisions incomplete. Second, communication nodes' computing needs cannot directly drive computing-node scheduling and still require manual configuration or platform intermediation, lengthening response chains. Third, user terminals as potential computing contributors cannot be directly perceived or invoked, leaving distributed computing value idle.

Yue Yujun's analysis based on actor-network theory shows that triple play is essentially the construction of a hypernetwork, attempting to break down the connectivity barriers among telecommunications networks, radio and television networks, and the Internet. However, because computing power and computing-power coordination were not yet mature at that time, the triple play process left a large number of "structural holes," resulting in insufficient network connectivity and limited synergy.

2.3. Centralized Decision-Making: Institutional Suppression of Edge Autonomy

The third core characteristic of hypernetworks is distributed decision-making, in which edge nodes make autonomous decisions and self-regulate based on locally sensed information. However, decision-making power in the current communication system is highly concentrated in central nodes, and the autonomous decision-making capacity of edge nodes is subject to dual institutional and technical suppression.

From the perspective of power structure, the organizational inertia of the mass communication era still affects mainstream media, creating path dependence that is difficult to break. In such a pyramid-shaped organizational architecture, decisions must be reported and issued level by level, and grassroots editorial departments and technical departments lack space for autonomous decision-making.

A deeper problem lies in the fundamental contradiction between the centralization of decision-making in mainstream media and the operational logic of computing-power coordination. The essence of computing-power coordination is distributed, multi-objective, real-time dynamic optimization, which requires edge nodes to make autonomous decisions based on local state information. However, the current organizational model of mainstream media still emphasizes centralized

control and bureaucratic management. Even when edge nodes have the technical conditions, they find it difficult to obtain decision-making authorization. At the same time, although commercial platforms centered on algorithms have achieved “decentralization” in distribution logic, their decision-making power has not truly sunk to users or edge nodes; rather, it has shifted to platform algorithms as a new “black-box center.”

2.4. Lagging Institutional Adaptation: Institutional Inertia of Domain-Segmented Governance

Multiple node identities, heterogeneous direct connections, and distributed decision-making require not only technical conditions but institutional adaptation. Yet communication institutions remain based on domain-segmented governance, creating tension with hypernetworks’ cross-domain coupling. Computing, power, and communication fall under different regulators, policy frameworks, and regulatory logics; coordination among them is limited, let alone a unified framework under computing–power coordination.

This institutional inertia is even more prominent in the communication field. Traditional communication management systems are designed with content regulation at their core and lack effective regulatory and policy instruments for the materiality of communication infrastructure, such as data center energy consumption, computing scheduling efficiency, and network latency. Computing–power coordination, however, requires the communication system to focus not only on what content is communicated but also on how computing is scheduled and how power is responded to. This exceeds the capacity boundary of traditional communication institutions.

At the same time, the lag in the institutional environment reinforces the three dilemmas described above: the diversified expansion of node identities lacks a legitimacy basis and access rules; heterogeneous direct connections lack cross-industry data-sharing and interface standards; and the autonomous decision-making power of edge nodes lacks institutional authorization and accountability frameworks. The transformation of communication paradigms is not only an update of technical tools but also a redistribution of communication power structures. This redistribution must be accompanied by synchronized adjustment of institutional structures.

3. Construction Paths and Operating Mechanisms of the Communication Hypernetwork System

3.1. Construction Path: A Three-Stage Transition from the Initial Stage to the Deep Hypernetwork

This transition cannot be achieved overnight; technical, institutional, organizational, and conceptual changes have different rhythms. This paper proposes a three-stage

path:

Stage one is the initial stage. At this stage, node identities are mainly singular. Although some computing nodes have begun to acquire the functional identity of power nodes, this is far from widespread; the pattern in which computing nodes, power nodes, and communication nodes each perform their own functions remains dominant. Heterogeneous connections are sparse, and cross-system interactions are mostly completed indirectly through centralized intermediaries. Decision-making is highly concentrated in central nodes, and edge autonomy is weak.

Stage two is the collaborative stage. Its key tasks are “identity unlocking” and “establishment of direct connection channels.” Some nodes begin to acquire multiple identities: edge data centers simultaneously assume computing, communication, and power-response functions, and user terminals begin to be included in the scheduling field as distributed computing nodes. Preliminary direct sensing and control channels are established among power, computing, and communication nodes, and feedback latency is compressed from minutes to seconds.

Stage three is the deep hypernetwork. At this stage, nodes generally acquire multiple identities, heterogeneous connections exhibit high density and redundancy, and feedback latency is further compressed to milliseconds. Decision-making power sinks to edge nodes, and the system achieves distributed adaptive regulation through local self-organization.

The transition proceeds by gradually reconstructing node identities, connection density, and decision-making power to match the operational logic of computing–power coordination.

3.2. Core Mechanisms: Three Pillars Driving the Transition

Each stage of the three-stage transition requires specific mechanisms for propulsion. This paper proposes three core mechanisms:

1) Mechanism of multiplying node identities

The multiplication of node identities is the operational implementation of the “multidimensional embedding” characteristic of hypernetworks. Its core meaning is to enable as many physical entities as possible to simultaneously acquire multiple node functional identities, allowing them to cross traditional system boundaries and participate in communication–computing–power collaborative operations.

This involves three steps. First, activate communication functions in computing nodes: data centers and edge nodes should gain content caching and edge distribution, moving from backstage support to foreground participation. Second, embed computing functions in communication nodes: CDNs and media platforms should join the computing scheduling system and invoke or contribute resources according to real-time communication needs. Third, expand user-terminal identities: smartphones and smart home devices should enter the computing resource pool and, through sharing mechanisms, become distributed computing nodes.

2) Mechanism of heterogeneous direct connections and short feedback

Heterogeneous direct connections and short feedback are the connection-level embodiment of the non-hierarchy characteristic of hypernetworks. Their core meaning is to establish direct sensing and control channels among power nodes, computing nodes, and communication nodes so that information can circulate among heterogeneous nodes without passing through centralized intermediaries, thereby compressing feedback latency from minutes to milliseconds or seconds.

The key to this mechanism lies in channel construction at three levels. First, direct connection between power and computing. Power grid nodes broadcast electricity price signals, load states, and green electricity ratios in real time to adjacent computing nodes, enabling computing nodes to autonomously adjust task scheduling strategies based on power information. Second, direct connection between computing and communication. Communication nodes directly initiate computing task requests to computing nodes, attaching metadata such as task priority and timeliness requirements, enabling computing nodes to dynamically allocate resources according to communication needs. Third, direct connection between power and communication. In specific scenarios such as traffic spikes caused by breaking news, communication nodes can directly perceive power constraints and incorporate energy-consumption factors into decision-making while scheduling computing power.

The technical foundation is largely in place; the key is cross-system data interfaces and protocols, with support from real-time sensing and dynamic scheduling.

3) Mechanism of distributed decision-making and local self-organization

Distributed decision-making is the power-level embodiment of the adaptive evolution characteristic of hypernetworks. Its core meaning is to sink scheduling power from central nodes to edge nodes with local sensing capabilities, enabling edge nodes to make autonomous decisions within constrained scopes, and enabling multiple edge nodes to form temporary self-organizing networks through local negotiation.

The advancement of this mechanism requires accompanying organizational change. At the technical level, edge nodes need local state sensing and decision-algorithm support. At the organizational level, it is necessary to break the bureaucratic logic of reporting everything to the center and grant edge nodes decision-making authorization in specific scenarios. At the institutional level, it is necessary to establish accountability frameworks and coordination rules for distributed decision-making to avoid “decentralization” sliding into “centerlessness” and causing chaos.

A typical scenario of distributed decision-making is that when an edge node perceives local power tension, it automatically migrates non-urgent computing tasks to other nodes in areas with abundant power. The operational logic of computing–power coordination itself contains the gene of distributed

decision-making. Its multi-objective optimization decisions require local sensing and autonomous judgment capabilities of edge nodes, providing a reference for communication nodes to obtain local decision-making autonomy.

3.3. Power Reconfiguration: The Political-Economic Logic of Communication System Construction

The paths and mechanisms described above answer the question of “how to construct” at the technical level. However, the deeper resistance to construction often lies not in technology but in power. The hypernetwork is not only a change in technical form but also a reconfiguration of communication power structures.

Power has shifted from the vertical echelon of mass communication to new centers—cloud vendors, grid companies, and super-platforms—a relocation rather than dissolution of centers that underlies the four dilemmas.

In a deep hypernetwork, the source of power undergoes a fundamental change: power no longer comes from a fixed central position but from a node’s connectivity and local decision-making capacity. If a node can connect more types of heterogeneous nodes and possesses autonomous decision-making capacity locally, it has the influence to reconfigure resources in specific situations. The concept of “hub capacity” in hypernetworks is proposed along this logic: hub capacity refers to the resource-allocation influence that a node acquires by simultaneously connecting multiple types of heterogeneous nodes and possessing local autonomous decision-making capacity. Research in communication studies further shows that heterogeneous interaction at network positions plays a decisive role in the allocation of communication resources.

If mainstream media exist only as content producers, they connect only to a single type of node: users. When they simultaneously become participants in computing scheduling, collaborators in power response, and organizers of user terminals, the heterogeneous nodes they connect expand to multiple types, including computing nodes, power nodes, and user nodes. At this point, media organizations acquire hub capacity in the hypernetwork to allocate multiple resources. This capacity does not depend on a fixed position but on the functional diversity and connection activity of nodes in the network.

4. The Impact of the Hypernetwork Communication System on the Systemic Transformation of Mainstream Media

4.1. From “Central Position” to “Core Node” : The Transformation of Mainstream Media’s Role Positioning

In the traditional communication landscape, the power of mainstream media comes from their central position as communication hubs—information must pass through them to reach the public. However, in the hypernetwork form, the “center” itself is fluid, and mainstream media cannot and should not attempt to restore a fixed

central position.

Social media platforms occupy important hypernetwork positions because they prioritize user and computing nodes rather than fixed centers; many mainstream media still rely on centralized content management systems.

For mainstream media, the true direction of transformation should be to enhance their node connectivity in the hypernetwork—connecting simultaneously to computing nodes, power nodes, user nodes, and institutional nodes—and to enhance local decision-making capacity, that is, the capacity to autonomously schedule computing and communication resources in edge scenarios. When a media organization is no longer merely a content producer but simultaneously a participant in computing scheduling, a collaborator in power response, and an organizer of user terminals, it acquires an irreplaceable functional position in the hypernetwork.

4.2. From “Going It Alone” to “Nested Networks” : The Transformation of Mainstream Media’s Organizational Form

The hypernetwork perspective requires re-examining the organizational boundaries of mainstream media. Client apps, official accounts, broadcasting networks, and websites are nested subnetworks embedded in the communication hypernetwork.

Nesting increasingly makes communication depend on computing power; core nodes are no longer determined solely by institutions and power, and user nodes now matter. Mainstream media should see themselves as complex systems of nested subnetworks, each a hypernetwork node forming heterogeneous collaborative links.

4.3. From “Content Production” to “Participation in Computing Scheduling” : The Expansion of Mainstream Media’s Functional Positioning

Under computing–power coordination, the functional positioning of mainstream media needs to expand from single content production to participation in computing scheduling. This is both a technological requirement and a strategic choice to rebuild irreplaceability.

They can expand at three levels: first, coordinate content distribution with computing scheduling by incorporating media platforms into computing scheduling and enabling real-time resource invocation or contribution; second, coordinate edge nodes with power response by migrating non-urgent tasks from power-tight to power-abundant areas; third, coordinate user terminals with distributed computing by including terminals in the resource pool and turning them into distributed computing nodes through sharing mechanisms.

In practice, some mainstream media have already moved AI inference to edge nodes, shifting from backstage support to foreground participation and from a single node to a multifunctional hypernetwork node.

4.4. From “Domain-Segmented Governance” to “Cross-Domain Coordination” : Requirements for Institutional Environment Adaptation

Hypernetwork construction requires institutional as well as technical adaptation; mainstream media transformation needs synchronized institutional adjustment.

Institutional adaptation requires action at the following levels. First, establish a system of mutual recognition of node identities so that the multiple identities of computing nodes, power nodes, and communication nodes obtain a legitimacy basis and access rules. Second, establish cross-industry data-sharing and interface standards to break down data barriers among power, computing, and communication. Third, establish accountability frameworks and authorization rules for distributed decision-making, granting edge nodes decision-making authorization in specific scenarios. Fourth, establish regulatory and policy instruments adapted to hypernetworks, bringing the materiality of communication infrastructure—such as data center energy consumption, computing scheduling efficiency, and network latency—into the regulatory field.

5. Conclusion and Discussion

This paper uses a hypernetwork perspective to examine structural transformation under computing–power coordination. Hypernetwork construction essentially transforms communication power from “vertical echelon distribution” to “networked fluid distribution.” For mainstream media, rebuilding influence depends not on competing for a fixed center but on enhancing node connectivity and local decision capacity. This paper remains largely theoretical; future research can use cases or empirical data to examine node interactions and institutional implementation.

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