**Availability of Datasets:** Most ML and DL models require a large volume of quality datasets for training. However, the availability of such datasets is limited in the area of PAT prediction for NoC.

**Integrated Power, Thermal, and Area Prediction Models:** Most existing studies independently focus on power or thermal optimization. Studies on simultaneous analysis of power, area, and thermal are rare.

**Scalability**: Many studies using the ML or DL model have been tested in specific architectures or smaller systems, but their scalability to larger multi-core environments is unclear.

 **Integrated Power, Thermal, and Area Prediction Models**: Most current studies focus on either power or thermal management, but integrated models that predict and optimize power, thermal, and area parameters simultaneously are rare. Developing an ML-based framework that can balance these competing factors in real-time could greatly enhance NoC efficiency.

 **Real-time Adaptability**: While machine learning models such as RL have shown effectiveness in thermal and power management, the need for real-time adaptability remains a challenge, especially when scaling to larger NoC architectures. Research could explore hybrid ML techniques that combine fast-learning models with slower but more accurate predictive algorithms.

 **Hardware Overhead Minimization**: Although some progress has been made in reducing the area overhead of ML-based predictive models, further optimization is needed. Research could focus on lightweight models that provide high predictive accuracy without significantly increasing chip area, potentially through the use of neuromorphic or in-memory computing approaches.

 **Dataset Augmentation for ML Models**: Effective machine learning models rely on large and diverse datasets. However, the availability of high-quality NoC-specific datasets is limited, especially for area efficiency prediction. Research could focus on generating synthetic datasets or using data augmentation techniques to improve the training and robustness of these models​

 **Integrated Power, Thermal, and Area Optimization**: Most existing studies focus on addressing thermal or power optimization independently. There is a need for models that simultaneously address all three parameters in real-time for better overall system efficiency.

 **Scalability**: Many models, particularly those utilizing reinforcement learning (e.g., Q-Thermal, TTQR), work well in specific architectures or smaller systems but have not demonstrated clear scalability to larger multi-core environments.

 **Hardware Overhead**: While several approaches improve power and thermal management, they often increase the area overhead (e.g., Q-Thermal). Future work could explore lighter ML models to minimize the area cost.

 **Dynamic Adaptation**: Some methods (e.g., TTNNM) focus on offline optimization, which lacks consideration for dynamic runtime changes in workload or thermal conditions. Adaptive, real-time machine learning models could fill this gap.

 **Robust Datasets**: Many machine learning approaches depend on large, high-quality datasets for training. However, there is limited work on dataset augmentation and diversity for area prediction and multi-factor optimization.

 **Limited Routing Algorithms**: Many approaches, such as those in papers [1], [2], [5], [6], and [13], use the **XY routing algorithm** for traffic management. This limits adaptability to different network conditions. There is room for exploring advanced or hybrid routing algorithms that could improve efficiency across a wider range of NoC configurations.

 **Focus on Static Scenarios**: Techniques like in [13] focus on **offline inference scenarios**. The lack of real-time or dynamic adaptation to temperature changes limits their applicability to real-world, runtime scenarios. A gap exists in developing approaches that can dynamically respond to traffic and thermal changes during execution.

 **Power-Thermal Correlation**: Some studies focus on either **thermal** [1], [2], [4], [9], or **power** [5], [6] issues, but few papers explore the **interaction between power consumption and thermal effects** comprehensively. Better models considering the correlation between power and thermal metrics during NoC operation are needed.

 **Scalability to Larger NoC Systems**: Methods like the **LSTM-based temperature prediction** in [16] are tested on smaller NoC systems (e.g., 8×8×4). Their **scalability to larger systems** is unclear, indicating a gap in understanding how these models perform in larger, more complex NoC architectures.

 **Thermal Hotspot Prevention**: Although **hotspot prevention** techniques like in [9] are promising, the challenge remains in **optimizing both traffic and temperature simultaneously** without significant overhead. Further research is needed on efficient trade-offs between performance, power, and temperature.