# Performance Analysis of MIH based Multihoming Approach of Vertical Handover in Heterogeneous Wireless Networks

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***Abstract***

*Mobility management in heterogeneous wireless networks is always considered as a challenging task in terms of interoperability, service availability and session continuity. This research proposes a new IEEE 802.21 based multihoming architecture for vertical handover between heterogeneous wireless networks. The framework is used to optimize handover at link layer (L2) and network layer (L3). Media Independent Handover (MIH) layer is added in the protocol stack which uses its defined services for network detection and selection. It collects information from link and network layer and forwards them to upper layers which are used to take optimized L2 and L3 handover decision. In addition, Mobile IP is incorporated with multihoming for simultaneous bindings for Mobile Node (MN). This hybrid approach reduces network selection time and improves data throughput and end-to-end delay. Using MIH, available networks are detected ahead of time and binding with the target network is achieved. The proposed approach is implemented in Network Simulator (ns-2). The comparative analysis of simulation results show that the proposed approach has improved data throughput and end-to-end delay by 49.8% and 89.9% respectively.*

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***Keywords:*** *IEEE 802.21 MIH, Multihoming, WiMAX, Wi-Fi*

## 1. Introduction

Mobility management across heterogeneous wireless networks is in great focus now-a-days. Much of the current research is focused to find an efficient approach to vertical handover between WiMAX and Wi-Fi networks. Such approach can benefit the Mobile Nodes (MN) giving the advantages of both networks. MNs can use the wide area coverage of WiMAX to roam around. In addition, MN can make intelligent decision to switch the network while moving through the overlapped area of WiMAX and Wi-Fi. If application or user needs to take benefits of Wi-Fi and wants to stay in the hot spot coverage area then data flows should be shifted to Wi-Fi interface. The need is to develop an intelligent vertical handover algorithm that should consider the changing network conditions and accordingly decide to switch the network.

The algorithm proposed in [1] uses the hybrid approach of Media Independent Handover (MIH) and Multihoming (MMVH) to improve the system throughput handover delay. In this paper the proposed MMVH algorithm is simulated using ns-2. The obtained results show that system throughput and handover delay have been considerably improved. A number of existing approaches uses vertical handover to improve overall delay of the network switching [2-5].

The rest of the paper is organized as follows: Section II gives an overview of the proposed approach. In section III, mobility scenario and mobile node configuration is explained. Section IV describes the simulation results with system throughput and delay analysis. Finally, section V concludes the paper.

## 2. IEEE 802.21 (MIH) Based Multihoming Approach

IEEE 802.21(MIH) based multihoming is an hybrid approach to vertical handover across heterogeneous wireless networks. In this approach the Media Independent Handover (MIH) services of the framework of IEEE 802.21 [6] is combined with multihoming. In the system architecture MIH Function (MIHF) layer is added between link layer and network layer. This layer serves as a middle layer and interacts with the above and bottom layer to transmit the information received through local and remote events. Three types of MIH services are used at MIHF layer to make an intelligent decision of network selection and detection [5, 7]. MIH Event service is used to collect and transmit local and remote event notifications. MIHF receives the technology dependent link events through link layers of multiple interfaces integrated with MN. These link events are propagated to L3 as link triggers to make an intelligent decision. After processing these events at application/transport or network layer, MIH Commands are issued in response to the MIH events. Media Independent Information service is used to collect information about neighboring networks. The detailed architecture of the MIHF layer in the proposed MMVH is described in Figure 1. It shows the details of MIHF which interacts with the modules of upper and lower layer to generate events and commands for seamless handover execution. In mobile node layer 2, WiMAX and WiFi interfaces interact with MIH Function layer using MIH_LINK_SAP. The link events communicated from these modules are directed to MIH user layer. The neighbor Discovery module is used to discover available networks in the neighborhood. This information is forwarded to interface management (IFMNGMT) module, which after necessary processing calls Handover Module to perform handover if and when required.

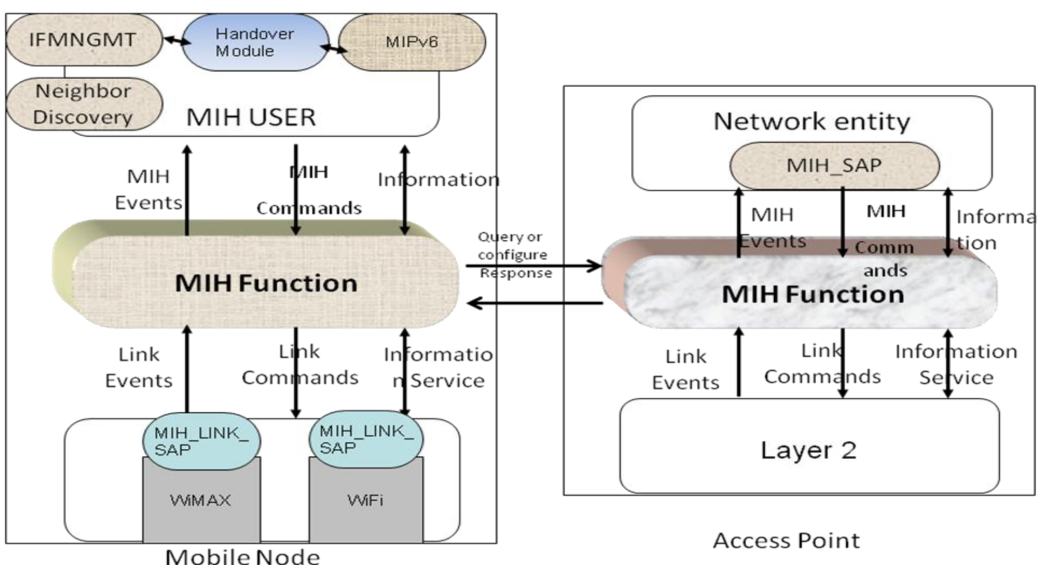


**Figure 1: System Architecture of MMVH**

The access point bock contains MIH function which directly communicates with MIH layer of MN. The network entity of access point consists of IP information and interacts with MIH function layer using MIH_SAP.

Figure 2 shows the signaling procedure of route updating using MMVH as MN travels from WiFi to WiMAX network. WiMAX is the default network for MN. The signaling procedure consists of four steps and starts with network scanning step. In this step DL-MAP, Uplink UL-MAP, Downlink Channel Descriptor (DCD) and Uplink Channel Descriptor (UCD) messages are used to discover the new network. DL-MAP is used at the receiver end and contains information about the frame structure. It starts with fixed encoding scheme and once decoded at the MAC layer used to give information about data burst decoding. UL-MAP is used to convey the information about uplink frames and frequency allocation. Similarly, DCD and UCD messages are exchanged periodically to share the information about modulation and coding schemes of downlink and uplink frames respectively. After the discovery of new router, with the reception of RtSolPr and PrRtrAdv, Home Address of new network is compared with that of MN which describes that whether the handover is within domain or inter domain. Once discovered, the necessary registration and authentication is performed by exchanging RNG-REQ, RNG-RSP, CID, REG-REQ and REG-REP messages. After that the routing information is updated and link of MN with the new network is setup.

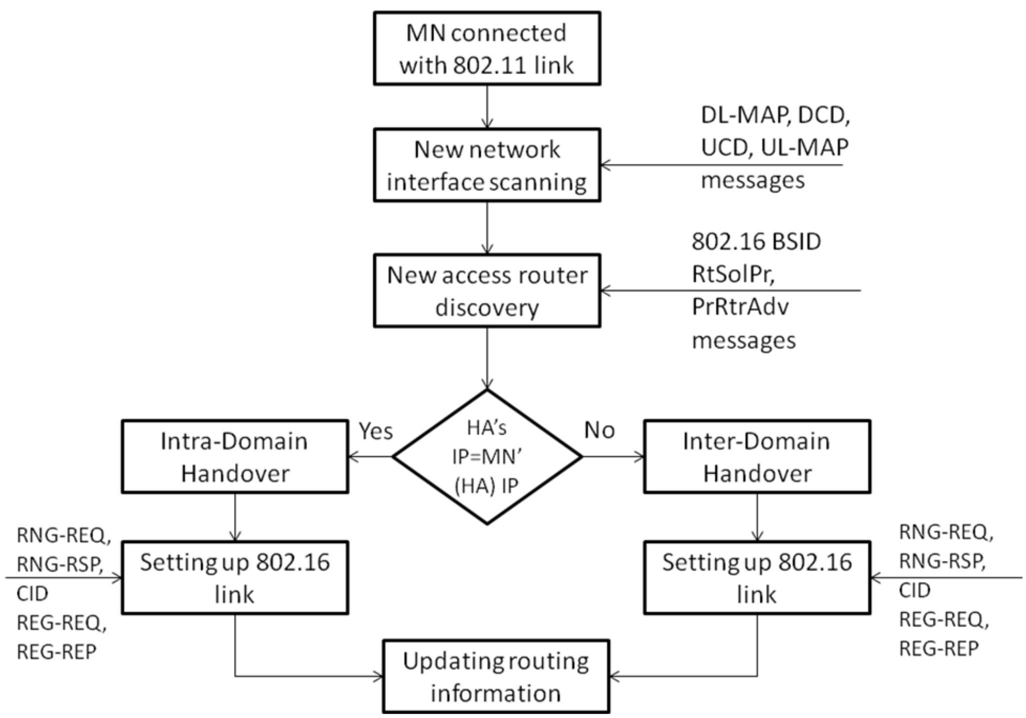


**Figure 2: Signaling Procedure of Route Updating using MMVH**

Figure 3 shows the sequence of events and information flow using proposed approach. The figure clearly demonstrates the concept of multihoming and use of multiple interfaces for efficient handover execution. It also describes the messages exchanged during the process. For the sake of generalization, some security and re-association message flow has also been shown in the figure. Initially MN is connected with WiMAX network, and upon reception of link_event_up message, the necessary function of MIH function layer are called to perform handover.

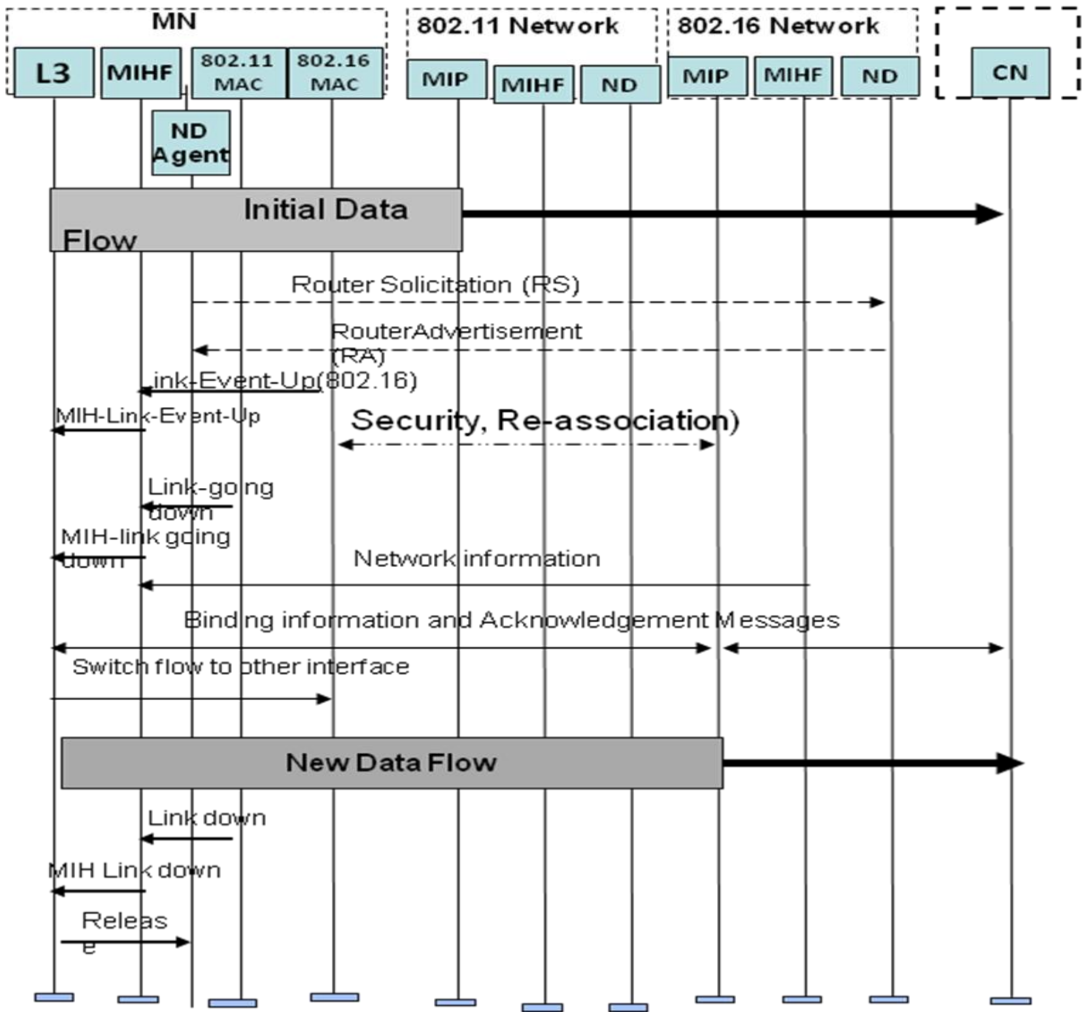


**Figure 3: Sequence of Events of MMVH**

## 3. Simulation Configuration and Mobility Scenarios

The proposed approach of vertical handover is implemented in Network Simulator (ns-2) [8]. Figure 4 shows the mobility scenario which is used to perform evaluation of proposed approach. Two available domains of scenario are WiMAX and WiFi, in which WiMAX is the default interface, i.e. at the start of simulation MN is connected to WiMAX BS (Base Station). For the sake of simplicity, BS of WiMAX and AP (Access Point) of Wi-Fi are connected to the internet through wired connection. The Corresponding Node (CN) is also connected to internet through wired network.

Initially MN gets connected to the internet through its default interface, i.e. WiMAX. When it wants to send data to CN, a path is established from BS to CN through wired network. MN transmits the packets to BS which then forwards them to CN through wired links. The traffic from CN to MN is forwarded on the reverse path in the similar manner. As Wi-Fi interface of MN receives the signals of new network, link events are forwarded from link layer to MIH layer of MN.

MIH forwards these events to IP layer for further processing. The SCTP multihoming at transport layer establishes two simultaneous connections for small amount of time, until the data flow is shifted from the current network interface to new one. Depending upon the available network bandwidth, required bandwidth of currently running application and available signal strength of currently connected network, i.e. WiMAX, decision to switch the data traffic on new network is taken. As this information is received and processed earlier than the connection breakage, therefore this approach reduces the risk of disconnection and so the risk of dropping packets during handover greatly decreases.

The movement pattern of MN is shown in the Figure 4. MN starts its movement from the WiMAX coverage area to the Wi-Fi coverage area. Due to the large coverage area of WiMAX, MN may stay in the area where both networks have strong signals. In this case, depending upon the available information, movement pattern and movement speed, the decision to remain in the current network may be taken; so that unnecessary switching of networks should not be performed which can greatly degrades the system performance.

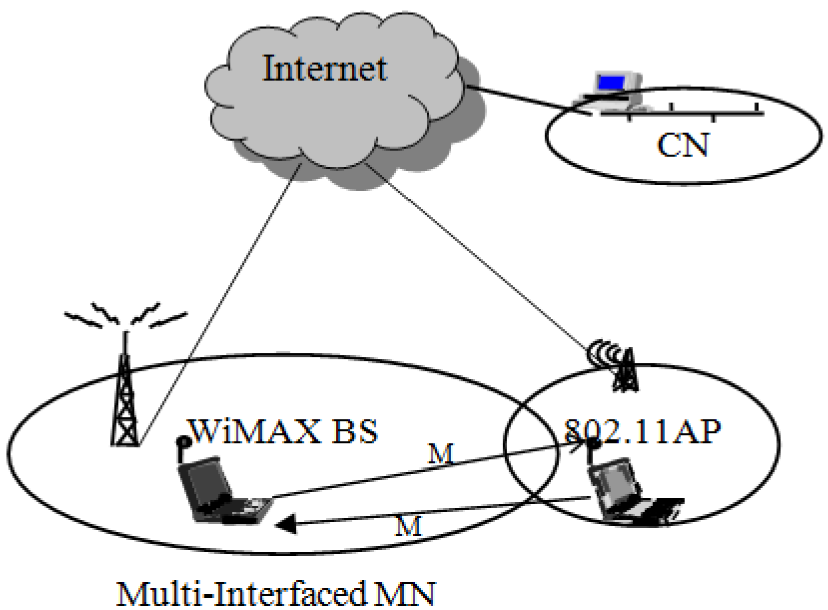


**Figure 4: Mobility Scenario of MN**

Simulation parameters of WiFi and WiMAX networks are listed in Table 1. These parameters are briefly described here to show the simulation strategy used in implementing the mobility scenario. Most of these are defined in the IEEE standard of WLAN and WiMAX [9]. The simulation module of 802.16 and seamless mobility implementing 802.21 framework has been used [10, 11] in this simulation. The SCTP transport layer protocol has been used to implement multihoming and it is integrated with IEEE 802.21 framework to achieve improved seamless and secure handover between heterogeneous networks.

**Table 1: Simulation Parameters**

| *SIMULATION PARAMETERS* | *VALUES* |
|---|---|
| *Data rate of WiFi* | *11 Mbps* |
| *Data rate of Wimax* | *50mbps* |
| *Freq Bandwidth ofWwimax* | *5e+6 MHz* |
| *Freq Bandwidth of WiFi* | *2.4GHz* |
| *Wimax modulation* | *16 QAM* |
| *Contention size* | *5* |
| *Mobile node speed* | *5-10 M/SEC* |
| *SIMULATION REGION* | *200 X 200 M* |

## 4. Simulation Results and Analysis

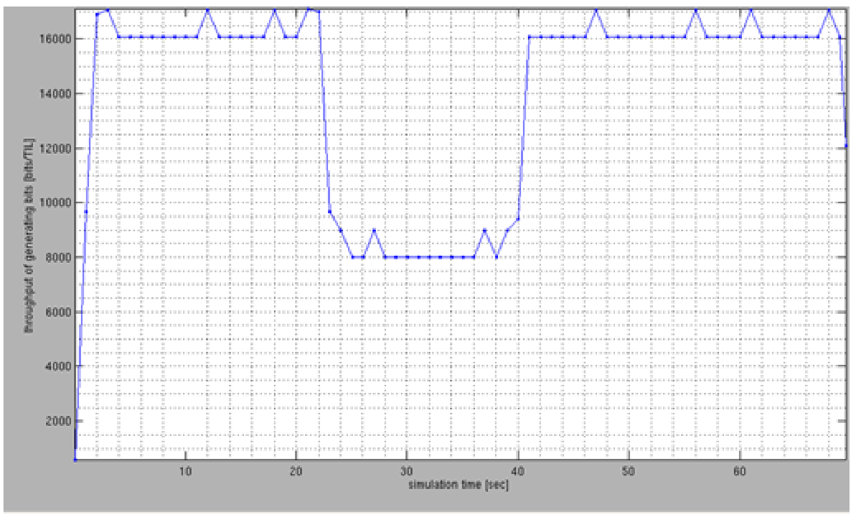


**Figure 5: Simulation Time (sec) vs Data Throughput (Kb/sec)**

Figure 5 shows the graph of data throughput (bits/sec) vs simulation time (sec). The throughput is scaled on y-axis and represented in number of bits generated per second. It is plotted against simulation time measured in seconds. As shown in the graph, the number of generated packet per second is highest at the start of simulation. As the MN starts moving (at time=5sec) throughput remains at highest level. The throughput has decreased at the time of handover from WiMAX to Wi-Fi (at t=22sec). The noticeable thing is that throughput is not decreased to zero during handover. As compared to vertical handover approach described in [12], where throughput decreased to zero during handover, this would be the advantage of using this approach that during vertical handover from one network to other, system throughput is not decreased to zero and so data flows are not disconnected during handover. As long as MN remains in WiFi network, the throughput of data remains in the range of 8Kb/sec to 10Kb/sec. After the handover of MN back to WiMAX network (time=40sec), throughput is improved again to 16Kbsec. This shows that WiMAX is favorable network for the MN in this scenario.

Figure 6 (a) shows the comparison of data rate (Kbits/sec) with respect to WiMAX and WiFi networks. The overlapped area in graph clearly indicates the importance of multihoming in vertical handover. As the handover trigger is generated in WiMAX network at t=18sec, the binding with WiFi network (t=21 sec) is obtained using dual IP address option of Multihoming module. In this way, data rate does not fall to zero during handover to other network. The graph also indicates that the overlapped interval is quite small. This is considered for network resource management. If the overlapped interval is high, then it may result in ineffective dissipation of network resources. During this overlapped interval, MN's IFMGMT module decides whether to initiate handover to new discovered network. Thus the decision should be fast enough to avoid any performance degradation.

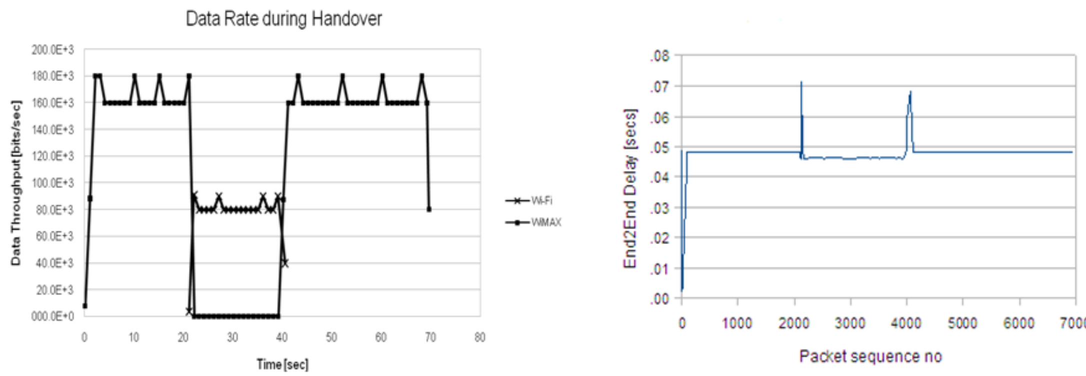


**Figure 6: (a) Data rate during handover b/w WiMAX and WiFi, (b) End-to-End Delay during Handover**

Figure 6 (b) shows the e-2-e delay graph of MN during handover. The end-to-end delay is plotted against packet sequence number. In the mobility scenario, initially MN remains in WiMAX network, but at t=22sec it switches its interface to WiFi network and uses that interface to transmit its data flows. After some time, i.e. at t=40 sec, it switches back to WiMAX network. At the time of handover, the delay increases due to handover signaling and data flow switching. The graph shows the delay at t=22sec (packet~2190) and at t=40 (packet~4003).

## 5. Performance Comparison

To evaluate the effectiveness of proposed approach, the comprehensive comparison of improved parameters is necessary with existing approaches of other researchers. Table 5.2 evaluates the proposed approach with respect to the Mo-Li et al approach [12] of vertical handover. The proposed approach is implemented on the same scenario as described in [12] and the performance of MMVH is analyzed with respect to given data on the said paper. The parameters which are listed in the table include data throughput, end-to-end delay and handover latency. The table also shows the percentage improvement of the parameters with respect to other approach. The handover latency in [12] is calculated on the bases of separate paths from HA to FA. For the sake of comparison, it is calculated for complete path according to the applied scenario which is 2x(39.9+4.7)=89.2 msec from HA→FA and from FA→HA.

**Table 2: Comparison of Parameters of Proposed Approach with Mo-Li Approach**

| Parameters | | Mo-Li Approach | Proposed Approach (MMVH) | %age Improvement |
|---|---|---|---|---|
| Data Throughput | Average | 710 Kbps | 816 Kbps | 14.9% |
| | During Handover | 205 kbps | 268.3 kbps | 30.8% |
| | | 0 kbps | 88 kbps | |
| End-to-End Delay | Average | 0.157 sec | 0.048 sec | 69.4% |
| | During Handover | 0.53 sec | 0.072 sec | 86.4% |
| | | 0.722 sec | 0.0699 sec | 89.9% |
| Handover Latency | | 89.2 msec | 68.538 msec | 23.16% |

## 6. Conclusion

The paper has analyzed the throughput and delay performance using IEEE 802.21(MIH) based Multihoming approach for vertical handover between WiMAX and Wi-Fi networks. Simulation results show that data loss during handover has decreased to zero and MN can switch its data flow during movement from one type of network to other, without breakage of currently connected data flow. The use of multiple interfaces in MN can raise certain issues of resource and power management, which can be an interesting future work.

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