جامعة نيويورك أبوظبي

NYU | ABU DHABI

Plug-and-Play Haptic Interaction for Tactile Internet based on WebRTC

Ken Iiyoshi[1], Ruth Gebremedhin[1], Vineet Gokhale[2], and Mohamad Eid[1]

[1]AIMlab, New York University Abu Dhabi, UAE
[2]Delft University of Technology, Netherlands

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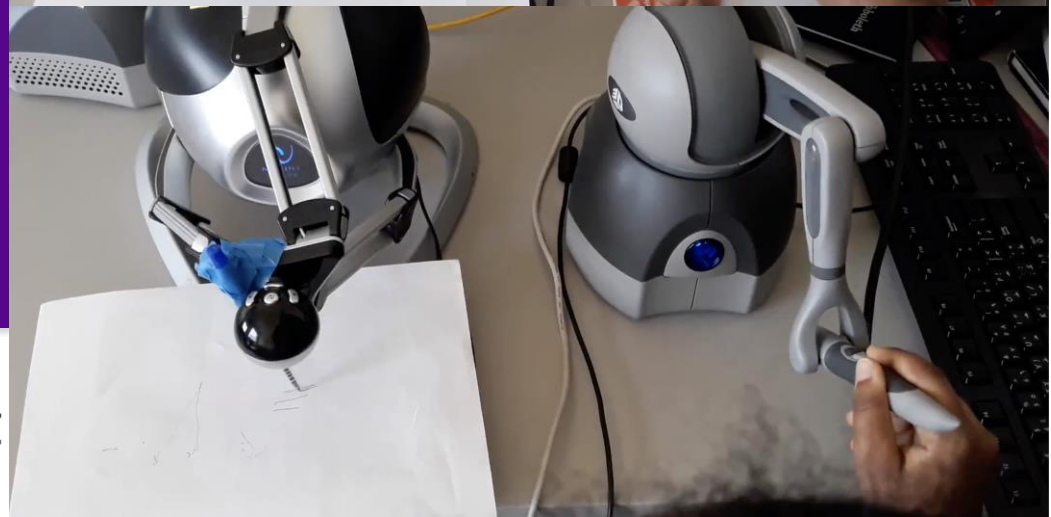

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Agenda

- **Introduction**
- **Related Work**
- **PnP Communication System**
- **Implementation of the PnP System using WebRTC**
- **Tele-writing Demonstration**
- **Conclusion and Future Work**

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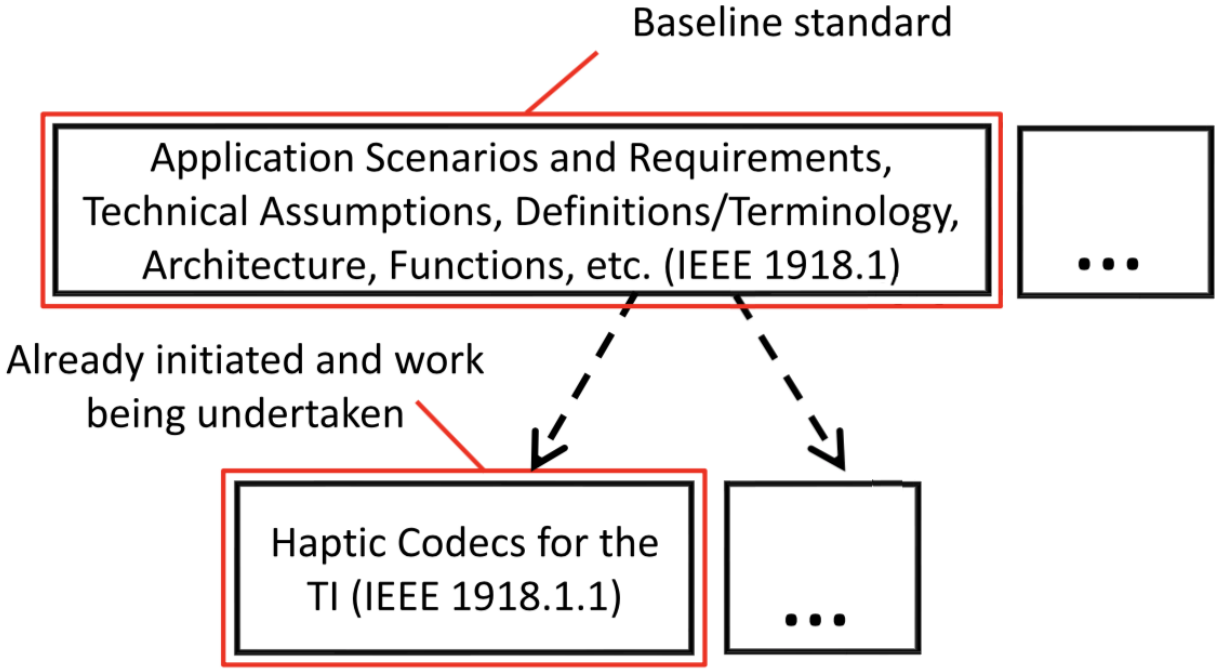
Introduction – Tactile Internet

- Tactile Internet (TI) enables physical interaction with remote objects.
- TI aims to achieve sub-10ms end-to-end latency and a packet-level reliability of up to 99.9999%
- TI has lead to the inception of IEEE 1918.1 working group (WG).
- IEEE 1918.1 Mission:
  - Define a standard framework encompassing a generic TI reference model and architecture,
  - Standardizing the interconnections between multitude of interfaces

Haptics in Tactile Internet



TI standards WG and its baseline standard as a foundation for future TI standards [2]. IEEE 1918.1 and 1918.1.1 are already initiated.

Haptic Codec Working Group (IEEE 1918.1.1)

- Standardize data reduction schemes for kinesthetic and tactile feedback
  - Kinesthetic Codec, with/without delay
  - Tactile Codec,
  - Haptic Metadata and Handshake Protocol
  - Objective Quality Evaluation
  - Subjective Quality Evaluation

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Haptic Codec Working Group (IEEE 1918.1.1)

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Related Work

- Carter et al. proposed an XML-based approach to represent generic haptic applications
- Cha el al. extended MPEG-4 Binary Format for Scenes (BIFS) for HAV media streams
- Eid et al. proposed HAML by to describe haptic-related information, including haptic interfaces, haptic development APIs, and quality of experience requirements
- A completely plug-and-play haptic communication system is yet to be fully developed

Plug and Play Communication System

- HAV Handshake
  - A three-way handshake protocol for the exchange of haptic-audio-video (HAV) metadata between TI nodes
- Tactile Internet Metadata (TIM)
  - Provide a technology-neutral description of the various characteristics and requirements of TI systems
- HAV Media Communication
  - Communication of synchronous haptic, audio, and visual media

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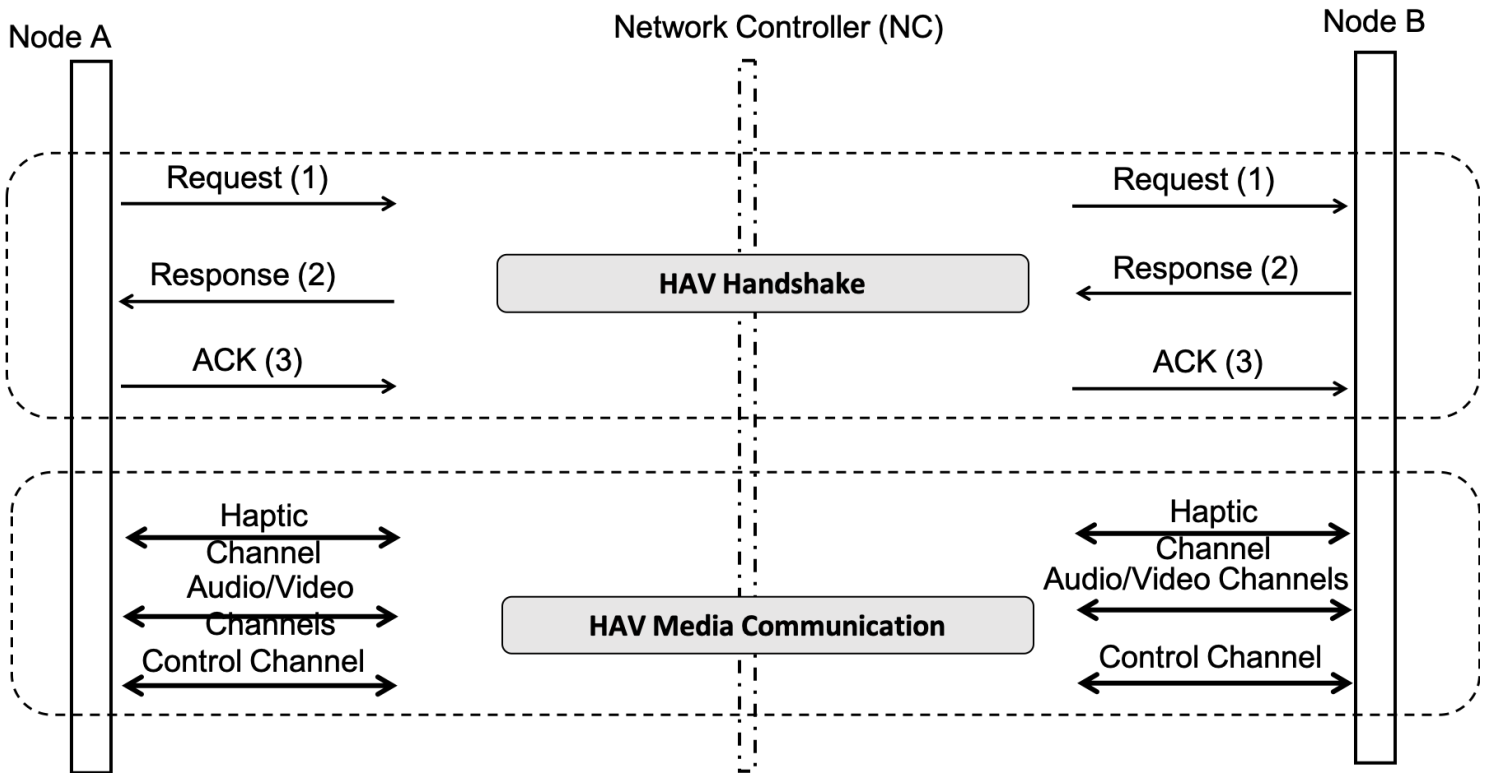
HAV Handshake



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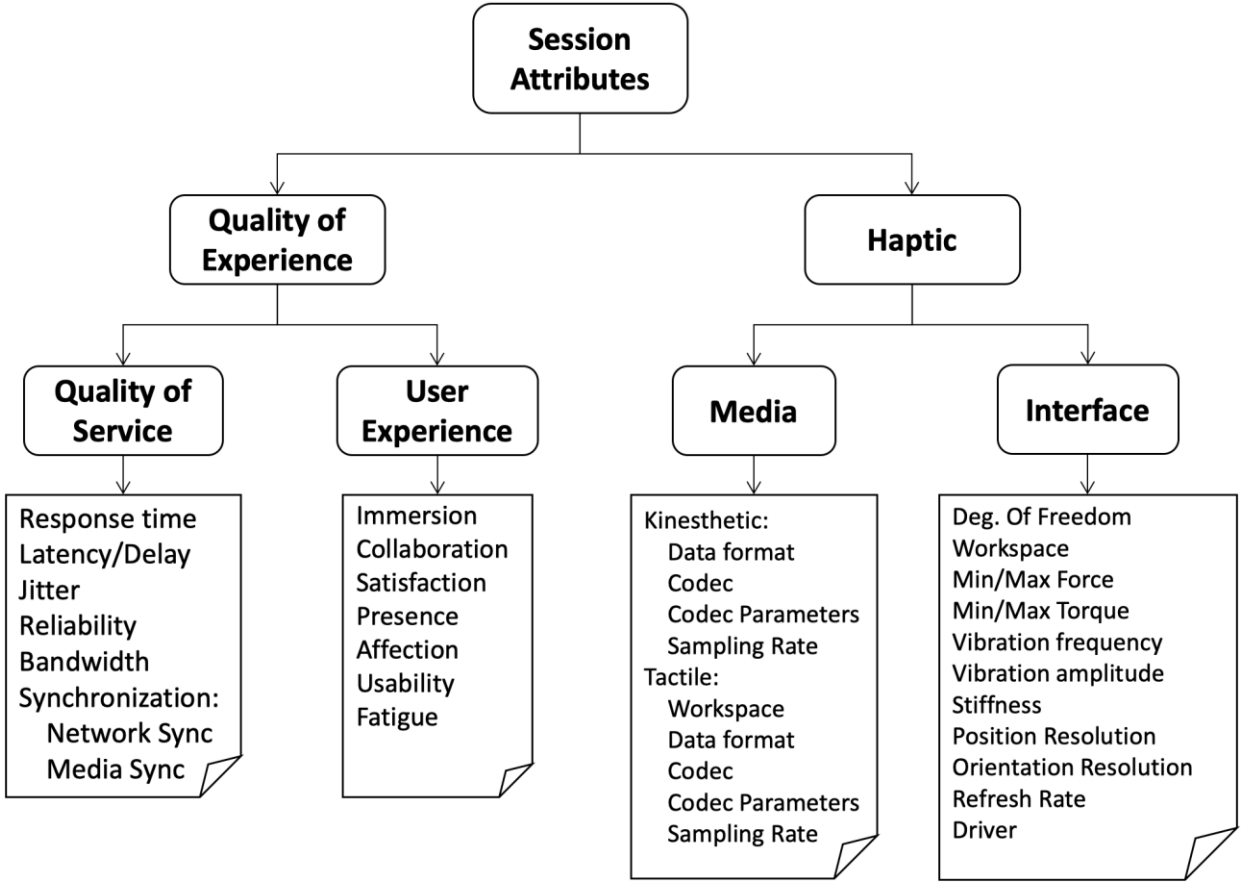
Tactile Internet Metadata (TIM)



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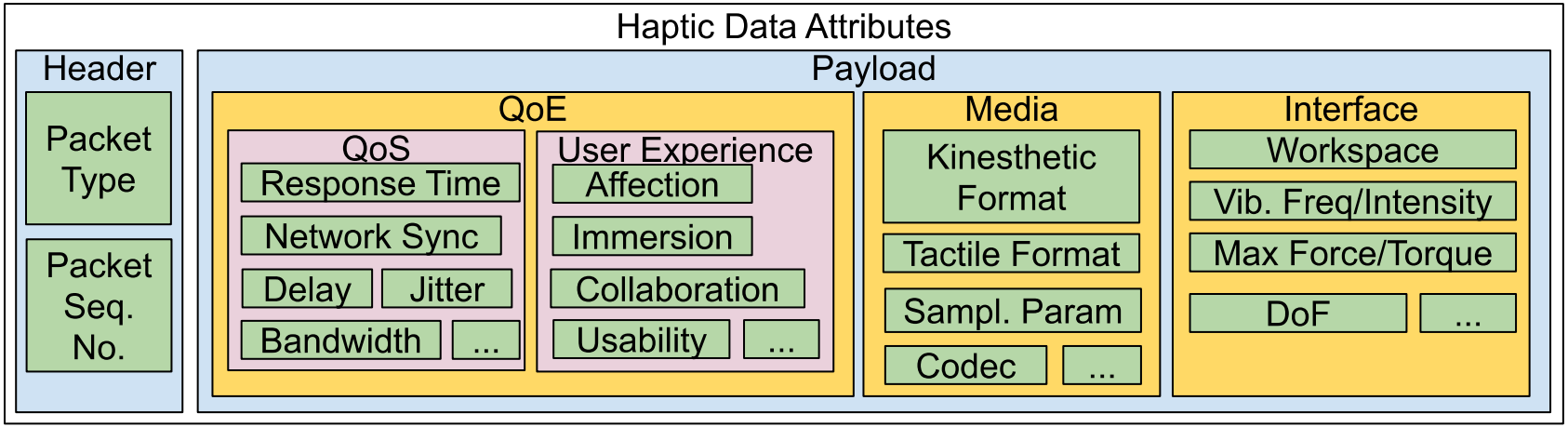
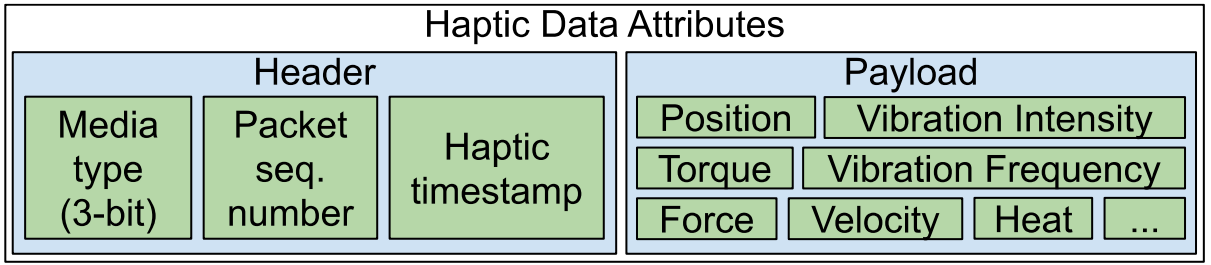
Handshake Message Format





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Implementation Using WebRTC

- Skype and Google Hangouts have established AV communication protocols
- Several open source options are available, such as easyRTC, WebRTC, Jitsi, etc.
- Web Real Time Communication (WebRTC):
  - Standardized through W3C and IETF
  - Enables real-time communication of audio, video and data in Web and native applications
  - Based on UDP for data communication
  - Allows flexible control of RTCDataChannel

Sample Request Packet (TIM)


```
{"packetType":"request",
 "payload"    :{"QoS"         :{"CommandDelay":0},
                "Media"       :{"ControlMode":true,
                                "FlagVelocityKalmanFilter":false,
                                "ForceDeadbandParameter":0,
                                "PositionDeadbandParameter":0,
                                "RecordSignals":false,
                                "VelocityDeadbandParameter":0.1},
                "Interface":{"actuatedGripper":false,
                             "actuatedPosition":true,
                             "actuatedRotation":false,
                             "gripperMaxAngleRad":0,
                             "leftHand":true,
                             "manufacturerName":"3D Systems",
                             "maxAngularDamping":0,
                             "maxAngularStiffness:0,
                             "maxAngularTorque":0,
                             "maxGripperAngularDamping":0,
                             "maxGripperForce":0,
                             "maxGripperLinearStiffness":0,
                             "maxLinearDamping":4,
                             "maxLinearForce":3.3,
                             "maxLinearStiffness":400,
                             "model":14,"modelName":"Geomagic Touch",
                             "rightHand":true,
                             "sensedGripper":false,
                             "sensedPosition":true,
                             "sensedRotation":true,
                             "workspaceRadius":0.075}}}
```


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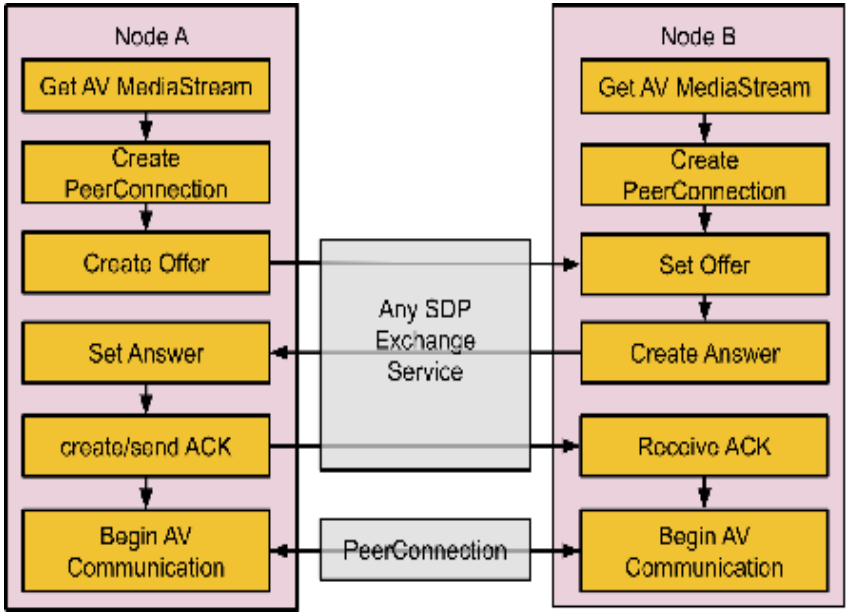
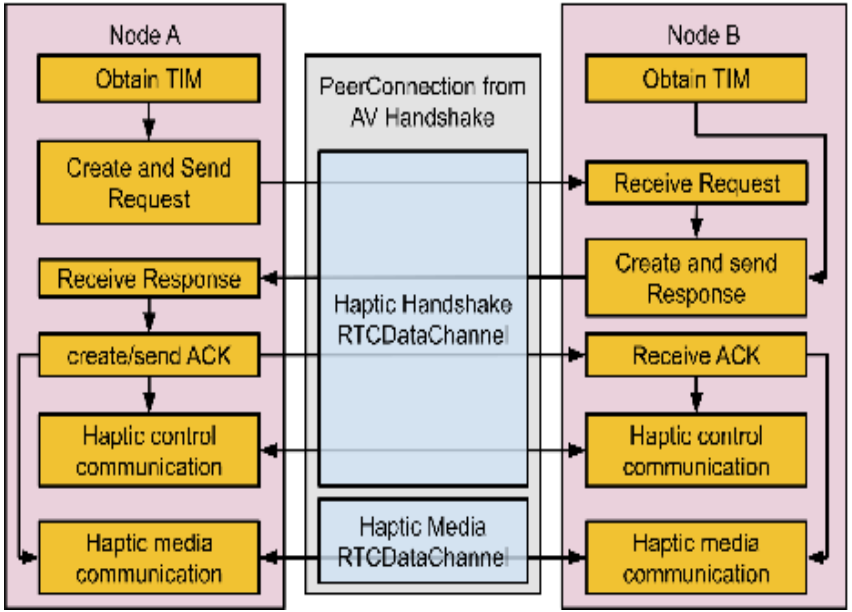
AV and Haptic Handshake



AV Handshake



Haptic Handshake

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HAV Media Communication

- The `RTCDataChannel` that was used for haptic handshake is reused for control communication
- A second `RTCDataChannel` is opened to be used for haptic media communication
- Configurable options:

```
const mediaChannelOptions = {[[Ordered]],
                             [[MaxPacketLifeTime]],
                             [[MaxRetransmits]],
                             [[DataChannelProtocol]],
                             [[Negotiated]],
                             [[DataChannelId]]};
```

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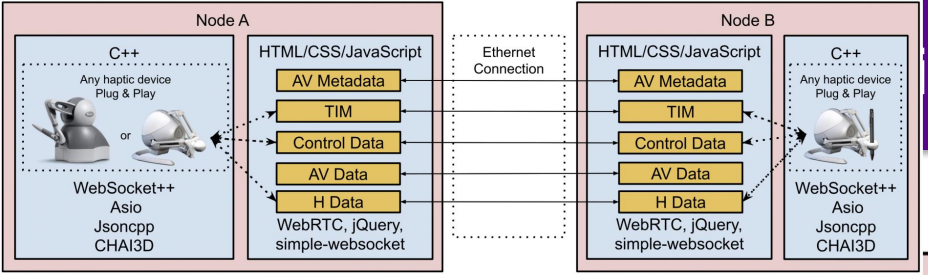
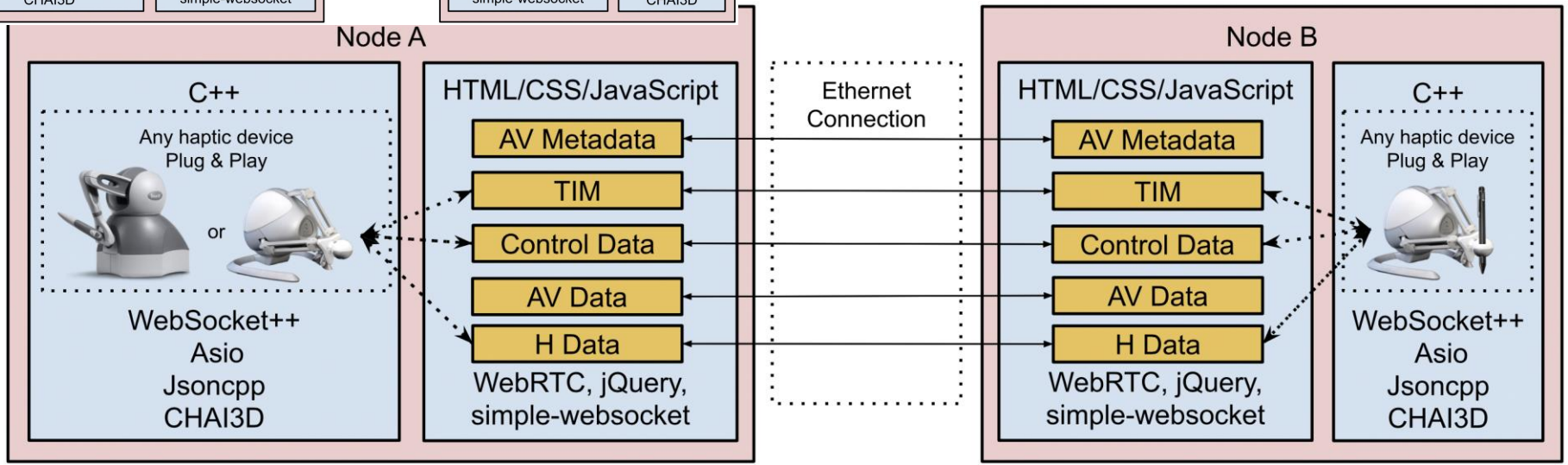
ting Application Implementation





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Tele-Writing Demonstration

Source code and demonstration available here:
https://wp.nyu.edu/aimlab/research_projects/havnetsimulation/

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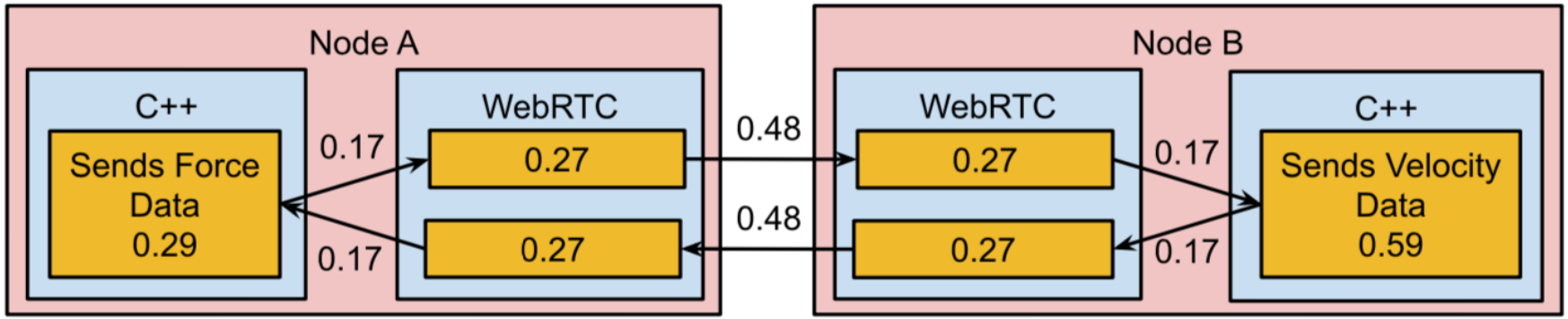
Experimental Results

- The mean and the standard deviation of the handshake latency is measured to be 47.25 ms and 23.38 ms, respectively
- The mean and standard deviation of RTT were 3.57ms and 1.81ms, respectively.



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Conclusions and Future Work

- A WebRTC-based PnP communication system for TI interactions encompassing haptic feedback.
- Sub-10 ms RTT delay performance enables haptic interaction
- Future work:
  - Test over a real Internet network
  - Evaluate with multiple haptic interfaces connected
  - Test multiple haptic modalities (tactile and kinesthetic)

Thank you very much!