Blockage-aware Multi-armed Bandits for Proactive Handover in mmWave Vehicular Networks

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Introduction

Millimeter-wave (mmWave) vehicular networks promise high data rates for Connected Autonomous Vehicles (CAVs) but suffer from blockage sensitivity and unstable connections. This work proposes a blockage-aware proactive handover scheme using Contextual Multi-Armed Bandit (CMAB) to address sudden signal outages in high-mobility V2X scenarios. Unlike reactive approaches, our method predicts future blockage rates by analyzing vehicle kinematics and large vehicle presence, enabling seamless handover decisions before signal degradation occurs.

Research Challenges

Penetration Loss

- Small coverage areas
- Blockage sensitive

Line-of-Sight (LoS) Requirement

- Unstable connections
- Frequent link failures

High Vehicle Mobility

- Frequent handovers
- Dynamic environment

Current Research vs Our Solution

Current Solutions:

- Reactive handover schemes
- Time-to-trigger delays
- Future blockages uninvolved

Our Innovation:

- **Proactive link quality prediction**
- **Online Learning Capability**
- **Adaptive Performance**
- **Real-time Decision Making**

Research Scenario

Network Setup:

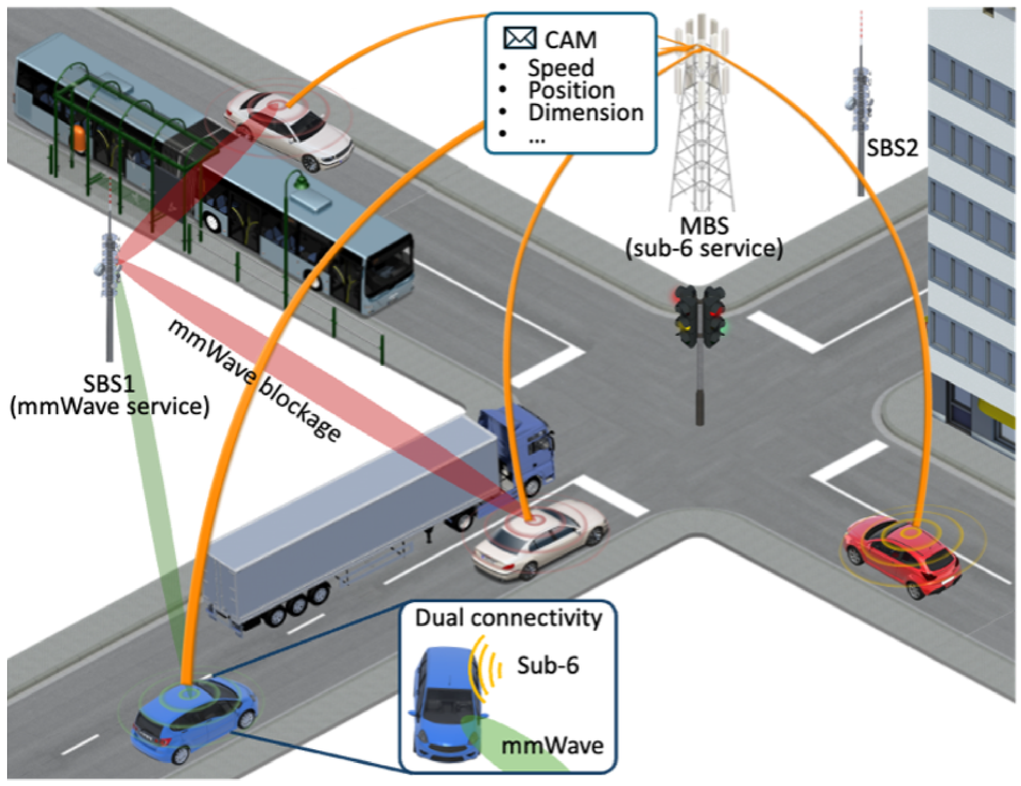
MBS:	Sub-6 GHz
SBS:	mmWave
Bus:	2.5×12×3 m
Car:	1.8×3×2 m
Bus prob:	0.8

CAM Functions:

- Vehicle Status Sharing
- Context Collection
- Trajectory Forecasting

CMAB Policies:

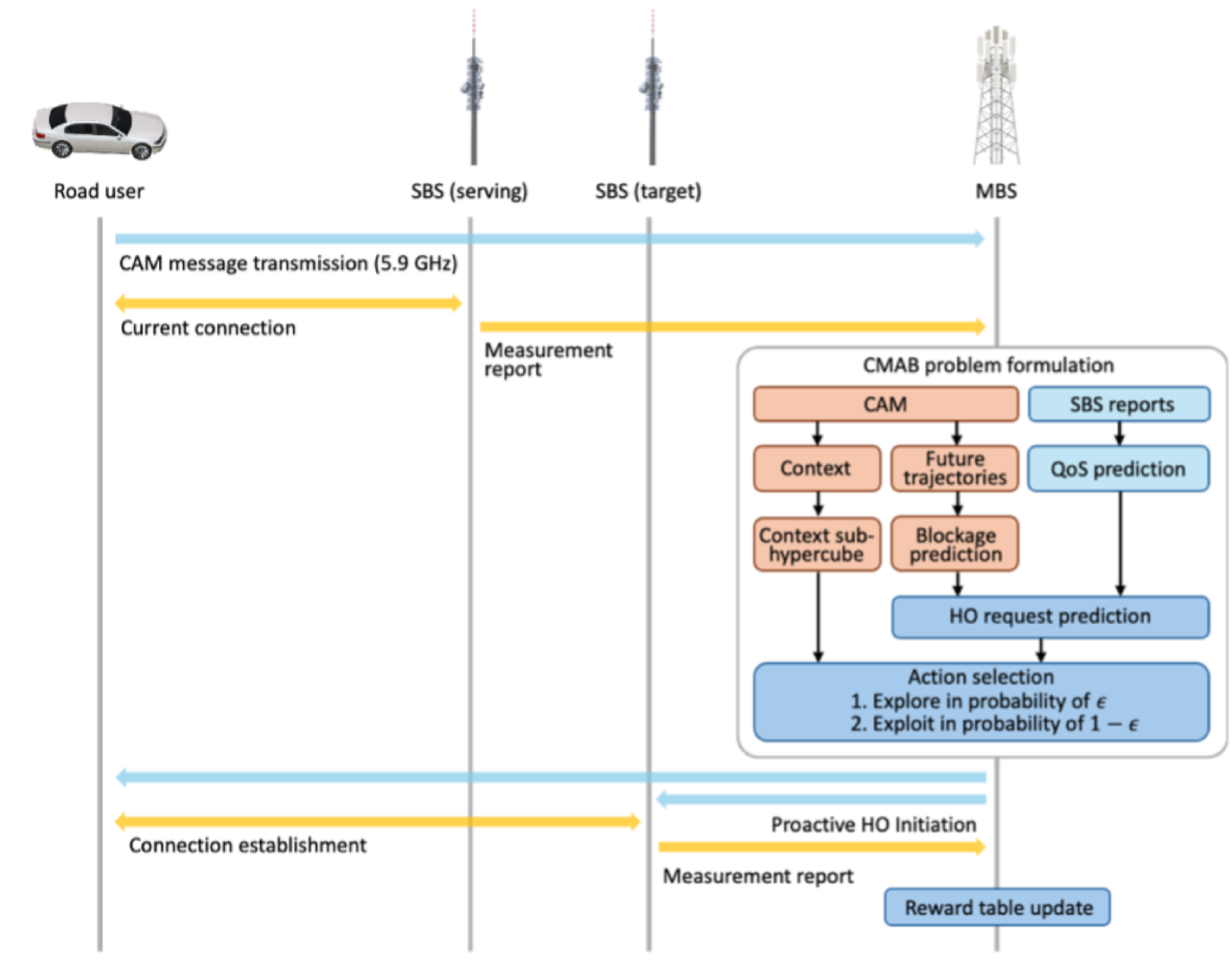
- UCB
- Thompson sampling



Research Scenario Description:

We examine a heterogeneous mmWave vehicular network with regions where a sub-6 GHz macro-Base Station (MBS) overlays multiple mmWave sub-Base Stations (sub-BSs). The MBS serves as both an access point and a centralized learner for the CMAB algorithm, while sub-BSs enable advanced V2X applications. Vehicles update their status via Cooperative Awareness Messages (CAM), providing essential input for blockage prediction and proactive handover decisions.

System Architecture



Three-Stage CMAB Process

Context Collection Stage:

- MBS collects vehicle CAMs via V2I
- Extract context vectors (velocity, acceleration, heading)
- Predict future blockage rates
- Serving SBSs report vehicle QoS

Handover Detection Stage:

- Monitor blockage status and QoS
- Trigger HO for long blockage duration
- Detect imminent QoS drops

Execution & Learning Stage:

- Explore vs. Exploit trade-off
- Select optimal SBS arm
- Update reward tables
- Cross-scenario learning improvement

Conclusions and Future Work

Future research will transition from the current centralized CMAB framework to distributed learning architectures, enabling vehicles and base stations to perform collaborative handover decisions through federated learning or multi-agent reinforcement learning approaches.