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Survivability Analysis of Device-to-Device Positioning

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Abstract

Device to Device (D2D) communication has a myriad of applications in the field of wireless communication. However, survivability aspect of D2D requires a closer observation in terms of different parameters. One such parameter is positioning of users in a D2D scenario. While traditional Positioning algorithms have been found to suffice for conventional mobile networks, they seem to lack sufficient survivability analysis under constrained situations. To alleviate this issue, the present work focuses on formulating a convex triangulation with survivability (CTS) algorithm by Improving the learning curve of the mobility in D2D networks, resource handoff can theoretically be sped up. As a result, the network can potentially more aware of its surroundings, thereby enhancing the positioning information associated with a resource user. Simulation results have been found to corroborate with the theoretical findings. The said method could be successfully implemented for applications such as search-and-rescue operations, emergency logistics, etc.

Keywords: Survivability, Device-to-Device, Localization, Convex Formulation, Positioning.

Introduction

A significant challenge in D2D positioning is maintaining reliable peer-based location estimates in the context of spectrum constraints, security vulnerabilities, and network disruptions. Efficient resource sharing, continuous verification mechanisms, robust positioning algorithms, and resilient infrastructure designs have been investigated during the last twenty years to guarantee that D2D systems can survive interference, malicious interference, and failures. The next sections outline some key recent advances that improve the overall survivability of D2D positioning frameworks.

Related Works

To optimize resource and to enhance security in D2D networks, a genetic algorithm has been applied to jointly optimize channel allocation and power levels in cellularly underlaid D2D setups while enforcing a minimum SINR for cellular links and allowing spectrum reuse among D2D pairs. Simulation results show an improved throughput compared to traditional greedy methods, due to the extensive exploration of feasible configurations by the algorithm [1]. In security, a continuous authentication protocol uses device attributes, including battery consumption, positional drift, and token validation, to maintain session integrity. Auxiliary identifiers and fallback keys provide resistance to denial-of-service, supported by formal analysis showing low overhead and proving resistance to identity theft in urban IoT deployments [2].

To advance the localization techniques for D2D positioning, a Monte Carlo localization has been augmented with inertial measurements for improved dead reckoning, enhancing the estimation accuracy in scenarios with sparse or compromised anchors. Under simulated attacks, positioning errors are reduced by roughly half compared to baseline methods through the refined approach, showing how sensor integration can be helpful for spoofing mitigation. [3] Wi-Fi fingerprinting challenges such as signal variability are resolved by stratified sampling of RSSI data, followed by autoencoder-based denoising and attention-enhanced LSTM processing. Evaluations on multiple indoor datasets give mean errors from 6.5 to 9.5 meters, beating previous neural approaches at handling large-scale environments. [4] Ultra-wideband ranging biases due to multipath effects have been corrected using convolutional networks, which allow transfer learning and thus require very little new data for adaptation. Peer-cooperative experiments demonstrate effective NLOS compensation, supporting dynamic scenarios in which full model retraining is not practical [5].

To observe the survivability in backbone and transport networks supporting D2D positioning, a probabilistic modeling of post-failure traffic delivery has been formalized as a distribution function, including metrics such as expected recovery rates and extreme percentiles. Applied to national backbone topologies, the model measures routing protocol performance under link failures, thus giving quantitative insights for disaster planning [6].

Energy conservation in 5G DWDM rings is facilitated by low-power monitoring tones that detect faults during the transceiver idle state. Dual protection balances efficiency with rapid response at negligible additional expense in all deployment types, thus improving availability[7]. Multi-domain optical scalability is increased by spectral partitioning into balanced sub-areas, which enables p-cycle computations to be done in a localized manner. Border links receive dedicated safeguards that reduce processing demands and spare capacity compared to unified global schemes[8].

Sensor scheduling on linear paths with survivability k aims to form multiple independent coverage groups to maximize operational lifetime. Polynomial flow optimizations yield validated duty assignments for various k such that no coverage lapses occur after multiple group failures[9]. By incorporating traffic engineering with failure probability estimates, disjoint path pairs are selected so as to minimize overall outage probabilities subject to congestion constraints. Against correlated hazard models, the hybrid approach achieves higher restoration success at lower overhead compared to segregated optimizations[10]. These collectively outline techniques for local tuning, persistent validation, multi-modal placement, cost-effective monitoring, domain partitioning, redundant staffing, and risk-aware hedging. Hybrid integrations, such as embedding resource algorithms within resilient optical layers or adapting linear scheduling principles to anchor networks, may be part of future advances.

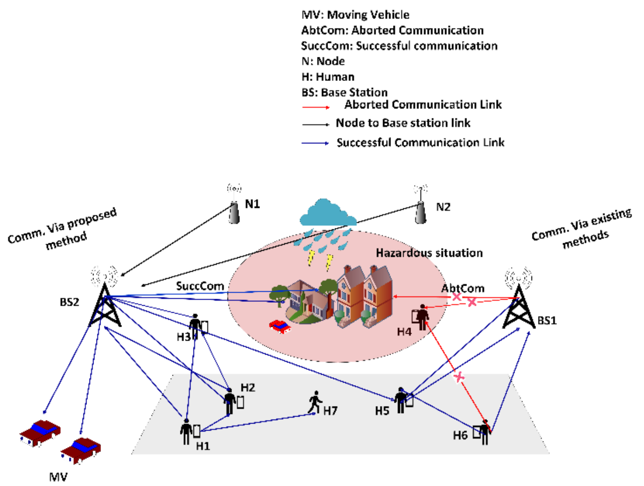
Proposed Method

In this section, the survivability aspect of a device-to-device network is described. The conventional functioning of the topology is affected due to a deviation in the position bearing of an unlicensed mobile device user. Under the assumption that an unlicensed device user is under constrained situation, the Mercator index is proposed, which indicates the measure of survivability to be optimized as defined here.

Definition 3.1: survivability-constrained device

We say that an unlicensed mobile device user $a_i^r \in A$ is *survivability-constrained* if it is naturally isomorphic to a device facing an aborted communication $h_4 \in H$ in a suitable region of resource allocation consisting of base stations BS_i and resource nodes N_i. To rephrase, a_i^r is *survivability-constrained* if and only if a_i^r is naturally isomorphic to the communication link pattern of h_4.

The constrained device a_i^r is the least survivable member of the network because it is quite susceptible to disconnection. Therefore, survivability of a network could be computed by determining the number of successful positioning information retrieval to the number of disconnections. Hence, we denote survivability through a proposed *Mercator index* which computes the convex triangulation amongst the device-to-device nodes in a network. An illustration depicting a survivability-constrained device is shown in Figure 1.



An illustration to show the survivability of D2D positioning under hazardous conditions. The proposed CTS method demonstrates increased stability in communications by maintaining successful links between nodes and base stations compared to current methods.

Based on the parameters mentioned in Table I., a computational environment was set up in MATLAB. The proposed Convex Triangulation based survivability analysis (CTS) algorithm is outlined in Algorithm 1.

Algorithm 1: Proposed Convex Triangulation Survivability (CTS) Algorithm

1: **Input**: Set of D2D nodes P= {1, 2, … n}, strategy set S_i for each node, payoff function $U_i(S_1, S_2, \dots, S_n)$, mobility data M, and dataset D.

2: **Output**: Survivable positioning layout matrix T, $mercator\ index$ $m_0(d)$ with stable trajectories and adaptive positioning resource handoff.

3: Initialize convex triangulation among nodes in P and construct payoff matrix using U_i

4: Generate initial topology parameters such as connectivity, link strength, and distance metrics

5: Introduce small variations in M to simulate chaotic mobility and identify stable attractors

6: For each node i: Evaluate all strategies in S_i, compute payoff U_i, and select the best response strategy

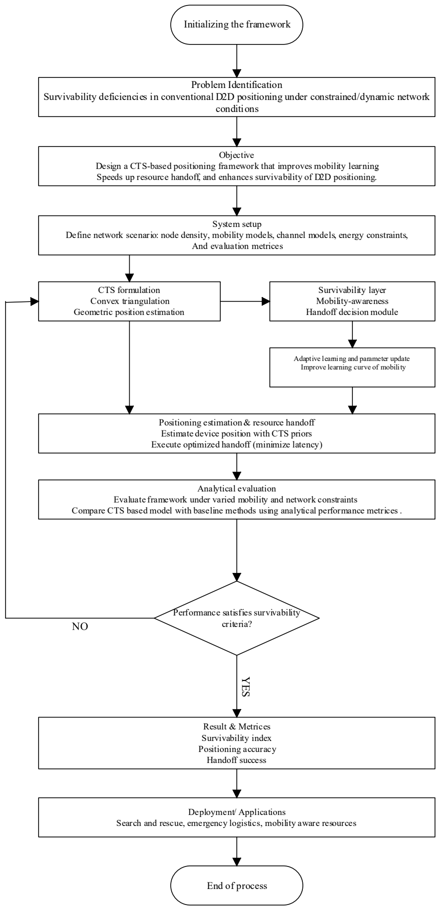
7: Update mobility states in M based on selected strategies to reflect real-time adjustments

8: Check equilibrium condition (no node can increase payoff by unilateral deviation)

9: Apply self-training on dataset D using known outcomes to update and refine strategies

10: Repeat until stable Mercator index $m_0(d)$ and survivable topology T are achieved.

A brief outlay of the proposed method has been shown through a flowchart in figure 2.



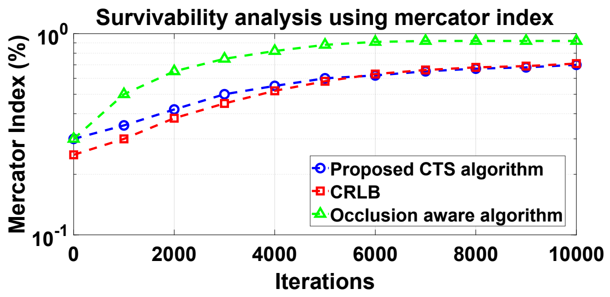
Flowchart of the proposed method.

Table of Parameters

Parameter	***Value***
Carrier frequency	2.4GHz
Bandwidth	10MHz
Transmit power of D2D users	23 dBm
Channel Model	i.i.d Rayleigh
Delay Tolerance	10–14 ms
Number of cellular users	4
Maximum distance between D2D pairs	10m
Maximum power of D2D transmitters	23dBm
Maximum power of cellular users	23 dBm
Wireline propagation delay	50 µs
Signaling rate	15kbits/s
Epoch	10000
Cell radius	500 m
Noise power density	-174 dBm
Aero propagation delay	0.12 ms
Message size	20 bytes
Number of resource blocks	8
Bandwidth of resource blocks	kHz

Results

The proposed CTS algorithm has been compared with the theoretical lower bound (Cramer-Rao lower bound [11]) and an occlusion-aware device to device algorithm [12], [13], as shown in figure 3.



Graph of survivability analysis using Mercator index

The proposed CTS algorithm exhibits strong and balanced performance, achieving results very close to the best-performing CRLB (red) while maintaining greater stability across iterations. It records only about **1–2%** higher Mercator Index than CRLB, indicating nearly equivalent efficiency, and performs around **15–20%** better than the Occlusion-Based Algorithm (green). At **10,000** iterations, CTS reaches approximately **9.0%**, compared to CRLB's **8–9%** and the Occlusion-Based method's **10–11%**. Overall, the proposed approach provides an excellent trade-off between accuracy, consistency, and robustness under varying conditions.

References

[1] H. Takshi, G. Doğan, and H. Arslan, "Joint Optimization of Device-to-Device Resource and Power Allocation Based on Genetic Algorithm," *IEEE Access*, vol. 6, pp. 21173–21183, 2018, doi: 10.1109/ACCESS.2018.2826048.

[2] A. Badhib, S. Alshehri, and A. Cherif, "A Robust Device-to-Device Continuous Authentication Protocol for the Internet of Things," *IEEE Access*, vol. 9, pp. 124768–124792, 2021, doi: 10.1109/ACCESS.2021.3110707.

[3] A. Bochem and H. Zhang, "Robustness Enhanced Sensor Assisted Monte Carlo Localization for Wireless Sensor Networks and the Internet of Things," *IEEE Access*, vol. 10, pp. 33408–33420, 2022, doi: 10.1109/ACCESS.2022.3162288.

[4] S. L. Ayinla, A. A. Aziz, and M. Drieberg, "SALLoc: An Accurate Target Localization in WiFi-Enabled Indoor Environments via SAE-ALSTM," *IEEE Access*, vol. 12, no. February, pp. 19694–19710, 2024, doi: 10.1109/ACCESS.2024.3360228.

[5] M. Mäkelä *et al.*, "Ubiquitous UWB Ranging Error Mitigation With Application to Infrastructure-Free Cooperative Positioning," *IEEE Journal of Indoor and Seamless Positioning and Navigation*, vol. 2, no. Ml, pp. 143–150, 2024, doi: 10.1109/jispin.2024.3384909.

[6] W. Molisz, "Survivability function - A measure of disaster-based routing performance," *IEEE Journal on Selected Areas in Communications*, vol. 22, no. 9, pp. 1876–1883, 2004, doi: 10.1109/JSAC.2004.829644.

[7] E. Wong, E. Grigoreva, L. Wosinska, and C. M. Machuca, "Enhancing the survivability and power savings of 5G transport networks based on DWDM rings," *Journal of Optical Communications and Networking*, vol. 9, no. 9, pp. D74–D85, 2017, doi: 10.1364/JOCN.9.000D74.

[8] H. Drid, B. Cousin, M. Molnar, and N. Ghani, "Graph partitioning for survivability in multi-domain optical networks," *IEEE Communications Letters*, vol. 14, no. 10,

pp. 978–980, 2010, doi: 10.1109/LCOMM.2010.090810.091923.

[9] X. Wan, J. Wu, and X. Shen, “Maximal Lifetime Scheduling for Roadside Sensor Networks with Survivability k,” *IEEE Transactions on Vehicular Technology*, vol. 64, no. 11, pp. 5300–5313, 2015, doi: 10.1109/TVT.2014.2381243.

[10] O. Diaz *et al.*, “Network survivability for multiple probabilistic failures,” *IEEE Communications Letters*, vol. 16, no. 8, pp. 1320–1323, 2012, doi: 10.1109/LCOMM.2012.060112.120353.

[11] T. S. Reddy, R. K. Arya, and Prateek, “Compensation of Coordinated Attacks in Underwater Internet of Sensor Networks,” *IEEE Transactions on Consumer Electronics*, vol. PP, no. 13, p. 1, 2024, doi: 10.1109/TCE.2024.3432785.

[12] J. Hu, A. E. Turgut, T. Krajnik, B. Lennox, and F. Arvin, “Occlusion-Based Coordination Protocol Design for Autonomous Robotic Shepherding Tasks,” *IEEE Transactions on Cognitive and Developmental Systems*, vol. 14, no. 1, pp. 126–135, Mar. 2022, doi: 10.1109/TCDS.2020.3018549.

[13] S. Chandra, Prateek, R. Arya, R. Sharma, S. Almansour, and M. Gandor, “Occlusion-Aware Secure Device-to-Device Communication in Social Internet of Things Networks,” *IEEE Transactions on Consumer Electronics*, vol. 71, no. 2, pp. 5119–5126, 2025, doi: 10.1109/TCE.2025.3570796.