The Implementation of Improved MPTCP in MANETs

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***Abstract*—In some special circumstances, e.g. tsunamis, floods, battlefields, earthquakes, etc., communication infrastructures are damaged or non-existent, as well as unmanned aerial vehicle (UAV) cluster. For the communication between people or UAVs, UAVs or mobile smart devices (MSDs) can be used to construct Mobile Ad Hoc Networks (MANETs), and Multipath TCP (MPTCP) can be used to simultaneously transmit in one TCP connection via multiple interfaces of MSDs. However the original MPTCP subpaths creating algorithm can establish multiple subpaths between two adjacent nodes, thus cannot achieve true concurrent data transmission. To solve this issue, we research and improve both the algorithm of adding routing table entries and the algorithm of establishing subpaths to offer more efficient use of multiple subpaths and better network traffic load balancing. The main works are as follows: (1) improve multi-hop routing protocol; (2) run MPTCP on UAVs or MSDs; (3) improve MPTCP subpaths establishment algorithm. The results show that our algorithms have better performance than the original MPTCP in achieving higher data throughput.**

I. Implementation of Improved MPTCP in MANETs

Fig. 1 shows a scenario of MPTCP in MANETs (MiM).

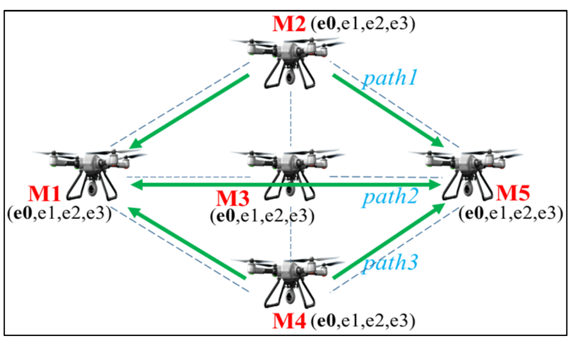

Fig. 1. The application scenario of MPTCP in MANETs.

A. Improving Multi-hop Routing Protocol

In this paper, OSPF MANET Designated Routers (MDR) is used as MHRP. In Fig. 1, MDR can only generate routing information for e0, however, MPTCP needs to build subpaths using the interfaces (e0,e1,e2,e3). Therefore, it is necessary to improve MHRP to provide routing support for the establishment of MPTCP subpaths, the improved method is as follow: generate routing table entries for e0, meanwhile, only one routing table entry is generated for each destination address (e1,e2,e3) respectively. The test result is shown in Fig. 4, the left shows the routing table of M1, which includes 6 routing entries to M5, the right shows the routing table of M5.

B. MPTCP on Android

It is the key for the implementation of MiM to run MPTCP on UAVs or MSDs, in this paper, we assume the operating system on UAV or MSD is Android. We port MPTCP to Android-x86-nougat (Android 7.1.1, kernel 4.4.62) based on the MPTCP implementation in the Linux kernel (MP-TCP). As can be seen in Fig. 2, a test is given to verify the function correctness of MPTCP in Android-x86-nougat.

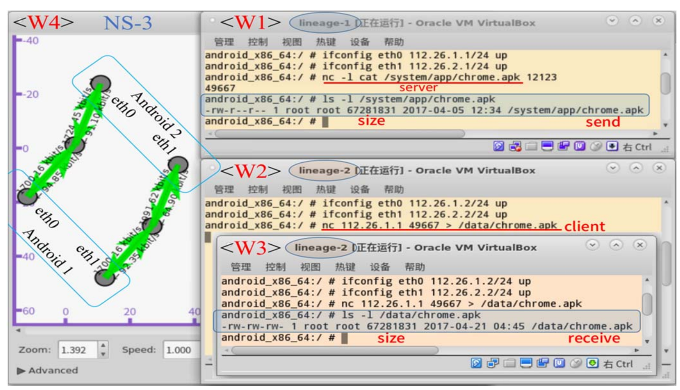

Fig. 2. Function testing of MPTCP in Android-x86-nougat.

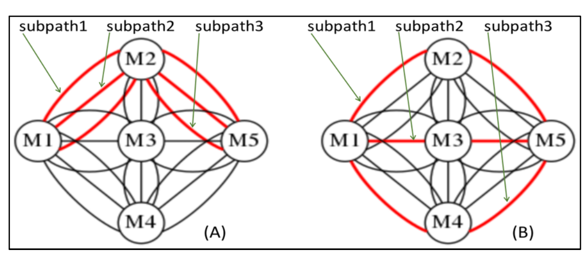

Fig. 3. Creating subpaths between M1 and M5.

C. Improving Subpaths Establishment Algorithm

Fig. 3-A shows the subpaths created by the original MPTCP

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at some moment. Fig. 3-B shows the subpaths created by the improved MPTCP. Table. 1 shows the subpaths established by the improved MPTCP. NoNH is the next hops number. NoNH =3 of master-subpath improves its connectivity reliability. The interfaces (M1-M5:e0) play three roles: 1. used by quagga to generate multi-hop routing entries; 2. used to establish master subpath; 3. to forward packets as mid-nodes. The interfaces M1-M5:(e1,e2,e3) are used to establish slave subpaths.

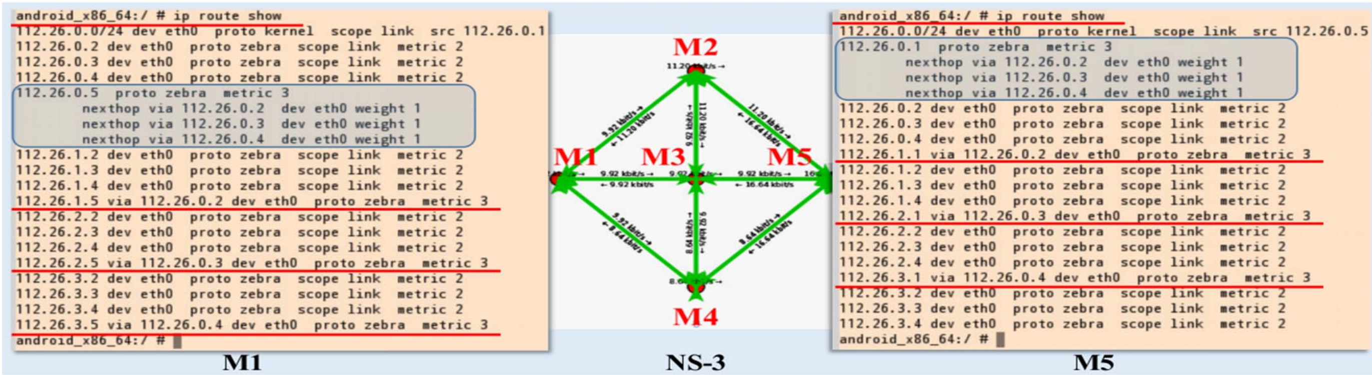

Fig. 4. The test result of improving multi-hop routing protocol.

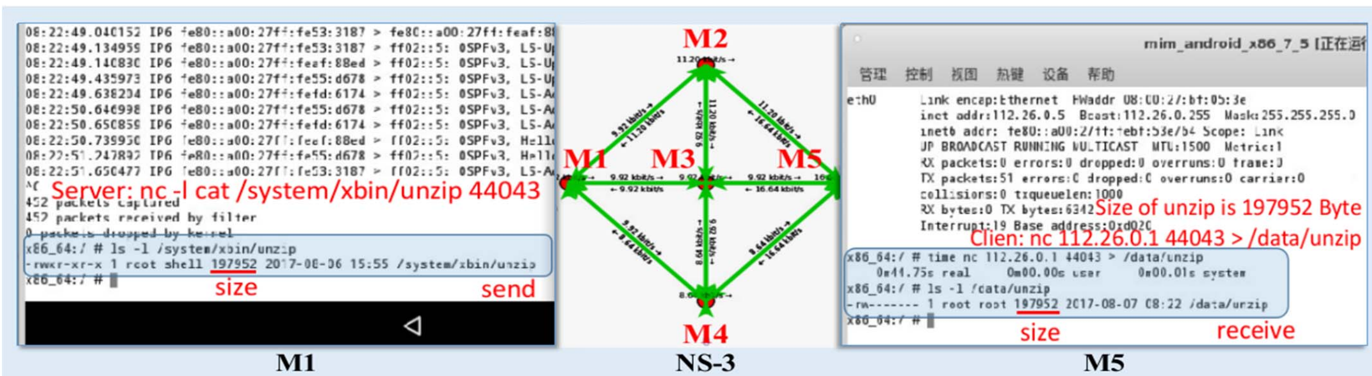

Fig. 5. Improved MPTCP is successfully running in MANETs.

Table. 1: The established subpaths.

subpath	src-IP	dst-IP	middle nodes	NoNH
master-subpath	M5:e0	M1:e0	M2, M3, M4	3
slave-subpath1	M5:e1	M1:e1	M2	1
slave-subpath2	M5:e2	M1:e2	M3	1
slave-subpath3	M5:e3	M1:e3	M4	1

II. Testing and Evaluation

The test environment is an IBM Server with 32-core 2.0GHz Intel Xeon CPU, 64GB memory, and 64-bit Fedora 24 installed. We create five VirtualBox instances for Android (mim_[1-5]), each of them has four network interfaces. Network topology is generated by NS-3 script [1]. We run command ***nc*** in M1 to make it as a file server, run command ***nc*** in M5 to download file *unzip* from M1. As shown in Fig. 5, the test results show that MPTCP is successfully running in MANETs.

We also carry out 30 times experiments to compare data transfer performances of TCP-MDR (TCP with Multi-hop Routing), MPTCP-MDR (original MPTCP with Multi-hop Routing), Improved-MPTCP-MDR (improved MPTCP with Multi-hop Routing). As shown in Fig. 6, Improved-MPTCP-MDR is better than TCP-MDR, however, MPTCP-MDR is worse than TCP-MDR. The reason (Fig. 3) is that original MPTCP can not distinguish which subpaths belong to one pair of nodes and which subpaths belong to multiple pairs of nodes.

III. Conclusion

In this paper, we research and improve the algorithms of both multi-hop routing and establishing subpaths in MANETs. The experimental results show that our algorithms can offer more efficient use of multiple subpaths and better network traffic load balancing.

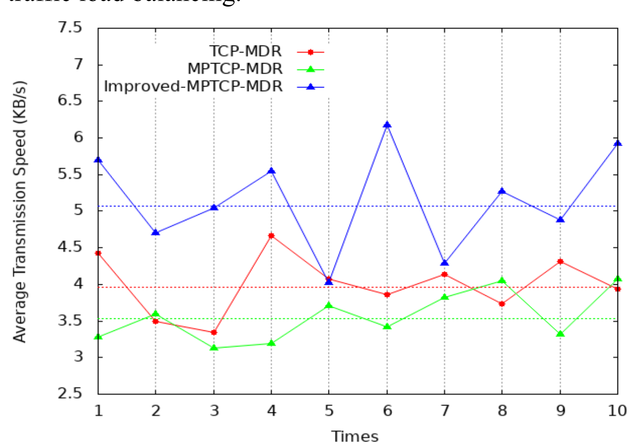

Fig. 6. Contrasting data transfer performances of TCP-MDR , MPTCP-MDR, and Improved-MPTCP-MDR.

References

[1] https://github.com/ztguang/MiM