sends it to the destination mobile node. A robust issue is guaranteeing that the segments are combined in the correct order. For this persistence, DTR specifies the segment structure format. Each segment contains eight fields, including:

(1) source node IP address(denoted by S)
(2) destination node IP address(denoted by D)
(3) message sequence number (denoted by m)
(4) segment sequence number (denoted by s);
(5) QoS indication number (denoted by q);
(6) data;
(7)length of the data; and
(8) checksum.

Fields (1)-(5) are in the segment head. The part of the source IP address field is to inform the destination node where the message comes from. The destination IP address field indicates the destination node, and is used to locate the final BS. After sending out a message stream to a destination, a source node may send out another message stream to the same destination node. The message sequence number differentiates the different message streams initiated by the same source node. The segment sequence number is used to find the correct transmission sequence of the segments for transmission to a destination node. The data is the actual information that a source node wants to transmit to a destination node. The length field specifies the length of the DTR segment including the header in bytes. The checksum is used by the receiver node to check whether the received data has errors. The QoS indication number is used to indicate the QoS requirement of the application. Thus, each segment's head includes the information represented by (S;D; m; s; q)(m; s = 1; 2; 3; :::). When a segment with head (S;D; m; s; q) arrives at a BS, the BS contacts D's home BS to find the destination BS where D stays via the mobile IP protocol. It then transmits the Segment to the destination BS through the infrastructure[20] network component. After arriving at the BS, the segment waits in the[14] cache for its turn to be transmitted to its destination node based on its message and segment sequence numbers. At this time, if another segment comes with a head labeled (S;D; (m + 1); s; q), which means that it is from the same source node but belongs to another data stream, the BS will put it to another stream[13]. If the segment is labeled as (S;D; m; (s+1); q), it means that this segment belongs to the same data stream of the same source node as segment (S;D; m; s; q). The combination of the source node's sequence number and segment sequence number helps to locate the stream and the position of a segment in the steam. In order to integrate the segments into their correct order to retrieve the original data, the segments in the BS are transmitted to the destination node in the order of the segments' [15] sequence in the original message. If a segment has not arrived at the final BS, its subsequent segments will wait in the final BS until its arrival.

Algorithm 1 Pseudo-code for neighbor node selection and message forwarding.

```
ChooseRelay( ) {
//choose neighbors with sufficient caches and bandwidth/queue (b/q) rates
Query storage size and QoS requirement info. from neighbors
for each neighbor n do
   if n.cache.size>segment.length && n.b/q>this.b/q then
      Add n to R = {r1, ... rm, ...} in a descending order of b/q
   end if
end for
Return R
}
Transmission( ) {
if it is a source node then
   //routing conducted by a source node
   //choose relay nodes based on QoS requirement
   R=ChooseRelay( );
   Send segments to {r1, ... rm} in R
else
   //routing conducted by a neighbor node
   if this.b/q ≤ b/q of all neighbors then
      //direct transmission
      if within the range of a BS then
         Transmit the segment directly to the BS
      end if
   else
      //relay transmission
      node_i=getHighestCapability(ChooseRelay( ))
      Send a segment to node_i
   end if
end if
}
```

Algorithm 2 Pseudo-code for a BS to reorder and forward segments to destination nodes.

```
//a cache pool is built for each data stream
//there are n cache pools currently
if receives a segment (S,D,m,s,q) then
   if there is no cache pool with msg sequence num equals m then
      Create a cache pool n + 1 for the stream m
   else
      //the last delivered segment of stream m has sequence num i − 1
      if s == i then
         Send out segment (S,D,m,s,q) to D
         i + +;
      else
         Add segment (S,D,m,s) into cache pool m
      end if
   end if
end if
```

V. EXPERIMENTAL EVALUATION

In DHybrid, a node first uses broadcasting to observe a multi-hop path to its own BS and then forwards a message in the ad-hoc transmission mode along the path. During the routing process, if the transmission rate(i.e., bandwidth) of the next hop to the BS is lower than a threshold, rather than progressing the message to the neighbor, the node forwards the message straight to its BS. The source node will be notified if an recognized path is broken during data transmission. If a source sends a message to the same destination next time, it uses the previously established path if it is not broken. In the Two-hop protocol, a source node selects the better transmission mode between direct transmission and relay transmission. If the source node can find a neighbor that has higher bandwidth to the BS than itself, it transmits the message to the neighbor [16]. Otherwise, it in a straight line conveys the message to the BS. The pretend network consists of 50 mobile nodes and 4 BSes. In the adhoc component of the hybrid wireless network, mobile nodes are randomly deployed around the BSes in a field of 1000_1000 square meters. We used the Distributed Coordination Function (DCF) of the IEEE 802:11 as the MAC layer protocol. The transmission range of the cellular interface was set to 250 meters, and the raw physical link bandwidth was set to 2Mbits/s. The transmission power of the ad-hoc interface was set to the minimum value required to keep the network linked for most times, even when nodes are in motion in the network. Then, the influence of the transmission range on different methods' performance is controlled. Specifically, we set the transmission range through the ad-hoc interface to 1.5 times of the average distance between neighboring nodes, which can be obtained by measuring the simulated network. We used the two-ray propagation model for the physical layer model. Constant bit rate (CBR) was nominated as the traffic mode in the experiment with a rate of 640kbps. In the experiment, we randomly chose 4 source nodes to constantly send messages to randomly elected destination nodes. The number of channels for each BS was set to 10. We expected that there was no capacity degradation during transmission between BSes. This hypothesis is realistic considering the advanced technologies and hardware presently used in wired infrastructure networks. There was no message retransmission for unsuccessful transmissions in the experiments. We employed the random way-point mobility model [17] to generate the moving direction, speed, and pause duration of each node. In this model, each node moves to a random position with a speed randomly chosen from. The pause time of each node was set to 0.

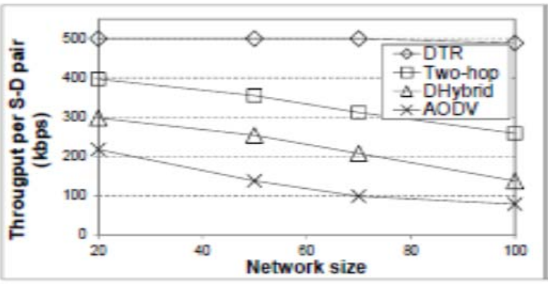

Fig. 4: Throughput vs. network size (simulation).

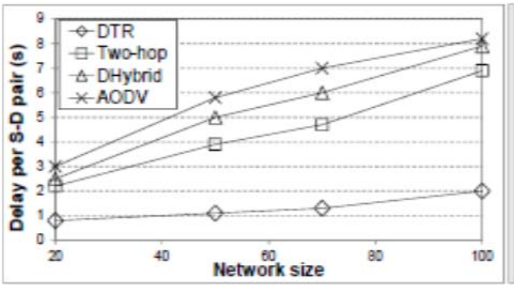

Fig. 5: Delay vs. network size.

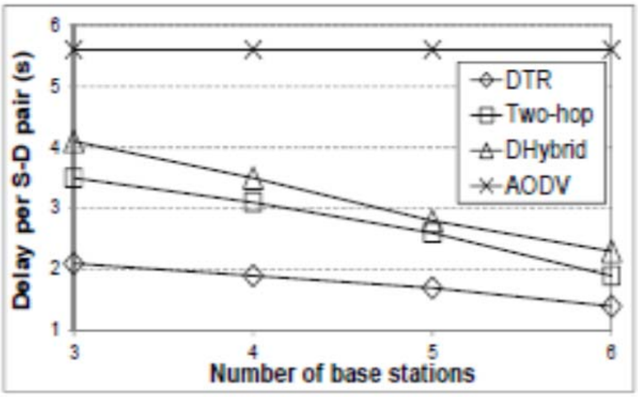

Fig. 6: Delay vs. number of BSes.

We set the number of segments of a message to the connection degree of the source node. The simulation warm up time was set to 100s and the simulation time was set to 1000s. We conducted the experiments 5 times and used the average value as the final experimental result. To make the methods comparable, we did not use the congestion control algorithm in DTR unless otherwise indicated. The short routing paths in Two-hop reduce congestion and signal interference, thus enabling better spatial reuse as in DTR. Meanwhile, Two-hop enables nodes to adaptively switch between direct transmission and relay transmission.[18]Hence, part of the transmission load is transferred to relay nodes, which carry the messages until meeting the BSes. As a result, gateway nodes connecting mobile nodes and BSes are not easily overloaded [19]. Therefore, the throughput of two-hop is higher than DHybrid.

VII. CONCLUSION

Present-day hybrid wireless networks merely syndicate the routing protocols in the two types of networks for data transmission, which thwarts them from accomplishing higher system capacity. In this, a Distributed Three-hop Routing Protocol to Increase throughput and makes chock-full use of pervasive base station in Hybrid Wireless Networks that integrates the dual features of hybrid wireless networks in the data transmission process. Here, a source node divides a message stream into segments and transmits them to its mobile neighbors, which further forward the segments to their destination through an infrastructure network. DTR limits the routing path length to three, and always arranges for high-capacity nodes to forward data. Its distinctive appearances of short path length short-distance transmission, and balanced load distribution provide high routing reliability and efficiency. DTR also has a congestion control algorithm to avoid load congestion in BSes in the case of unbalanced traffic distributions in networks. Theoretical analysis and simulated outcomes show that DTR can extremely expand the throughput capacity and scalability of hybrid wireless networks due to its high scalability, efficiency, and reliability and low overhead.

REFERENCES

[1] H Luo, R. Ramjee, P. Sinha, L. Li, and S. Lu. Ucan: A unified cell and ad-hoc network architecture. In Proc. of MOBICOM, 2003.

[2] P. K. McKinley, H. Xu, A. H. Esfahanian, and L. M. Ni. Unicastbased multicast communication in wormhole-routed direct networks. TPDS, 1992.

[3] H. Wu, C. Qiao, S. De, and O. Tonguz. Integrated cell and ad hoc relaying systems: iCAR. J-SAC, 2001.

[4] Y. H. Tam, H. S. Hassanein, S. G. Akl, and R. Benkoczi. Optimal multi-hop cellular architecture for wireless communications. In Proc. of LCN, 2006.

[5] Y. D. Lin and Y. C. Hsu. Multi-hop cellular: A new architecture for wireless communications. In Proc. of INFOCOM, 2000.

[6] P. T. Oliver, Dousse, and M. Hasler. Connectivity in ad hoc and hybrid networks. In Proc. of INFOCOM, 2002.

[7] E. P. Charles and P. Bhagwat. Highly dynamic destination sequenced distance vector routing (DSDV) for mobile computers. In Proc. of SIGCOMM, 1994.

[8] C. Perkins, E. Belding-Royer, and S. Das. RFC 3561: Ad hoc on demand distance vector (AODV) routing. Technical report, Internet Engineering Task Force, 2003.

[9] D. B. Johnson and D. A. Maltz. Dynamic source routing in ad hoc wireless networks. IEEE Mobile Computing, 1996.

[10] V. D. Park and M. Scott Corson. A highly adaptive distributed routing algorithm for mobile wireless networks. In Proc. Of INFOCOM, 1997.

[11] R. S. Chang, W. Y. Chen, and Y. F. Wen. Hybrid wireless network protocols. IEEE Transaction on Vehicular Technology, 2003.

[12] G. N. Aggelou and R. Tafazolli. On the relaying capacity of nextgeneration gsm cellular networks. IEEE Personal Communications Magazine, 2001.

[13] T. Rouse, I. Band, and S. McLaughlin. Capacity and power investigation of opportunity driven multiple access (ODMA) networks in TDD-CDMA based systems. In Proc. of ICC, 2002.

[14] H. Y. Hsieh and R. Sivakumar. On Using the Ad-hoc Network Model in Wireless Packet Data Networks. In Proc. of MOBIHOC, 2002.

[15] L. M. Feeney, B. Cetin, D. Hollos, M. Kubisch, S. Mengesha, and H. Karl. Multi-rate relaying for performance improvement in ieee 802.11 wlans. In Proc. of WWIC, 2007.

[16] J. Cho and Z. J. Haas. On the throughput enhancement of the downstream channel in cellular radio networks through multihop relaying. IEEE JSAC, 2004.

[17] B. Liu, Z. Liu, and D. Towsley. On the capacity of hybrid wireless networks. In Proc. of INFOCOM, 2003.

[18] H. Y. Hsieh and R. Sivakumar. A hybrid network model for wireless packet data networks. In Proc. of GLOBECOM, 2002.

[19] Y. Wei and D. Gitlin. Two-hop-relay architecture for nextgeneration WWAN/WLAN integration. IEEE Wireless Communication, 2004.

[20] X. J. Li, B. C. Seet, and P. H. J. Chong. Multihop cellular networks: Technology and economics. Computer Networks, 2008.

[21] B. Bengfort, W. Zhang, and X. Du. Efficient resource allocation in hybrid wireless networks. In Proc. of WCNC, 2011.

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