A Comparative Analysis of Reactive and Proactive Routing Protocols in Mobile Ad-hoc Networks

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Abstract**—** A wireless Ad-hoc network consists of a collection of geographically distributed nodes forming a temporary network with out the use of any additional infrastructure and no centralized control. MANETs need efficient routing protocols; therefore various ad-hoc routing protocols have been proposed and compared based on some metrics. This paper provides comparative performance analysis of Ad-hoc On Demand Distance Vector (AODV), Destination Sequenced Distance Vector (DSDV), Dynamic Source Routing (DSR) and Temporally Ordered Routing Algorithm (TORA) routing protocols. We have to analyze the performance metrics in terms of packet delivery fraction, average end-to-end delay, mobility, optimal route, packet loss and routing overhead. This evaluation and comparison study have been performed by means of simulation using NS2.

Keywords*— Keywords: Ad-hoc networks, Routing Protocols, AODV, DSDV, DSR, TORA, Performance Metrics and Mobility.

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I. INTRODUCTION

The area of ad-hoc networking has been receiving increasing attention among researchers in recent years, as the available wireless networking and mobile computing hard-ware bases are now capable of supporting the promise of this technology. An ad-hoc network is crew of wireless mobile nodes that creates a network without any assist of centralized administrator. It uses multi-hope point-to-point (P2P) routing as an alternative of stationary network communication to offer network connectivity [3]. Routing in ad-hoc networks has been a challenging task ever more since the wireless networks came into routine. The major motivation for this is the nature of ad-hoc networks where network topologies cannot be static [1]. The dynamic nature of Ad-hoc networks raises different performance challenges for routing protocols. To exchange information between different nodes, routing needs to be done by using different routing protocols. Therefore efficient routing protocols are key components of successful and improve the performance of communications. We have studied the different routing protocols used in Ad-hoc networks, and found that each protocol has different drawbacks and benefits depending on the network topology. Fig. 1 shows an example of an Ad-hoc network [1], where there are numerous combinations of transmission areas for different nodes. From the source node to the destination node, there can be different paths of connection at a given point of time. But each node usually has a limited area of transmission as shown in Fig. 1 by the oval circle around each node. A source can only transmit data to node B but B can transmit data either to C or D. It is a challenging task to choose a really good route to establish the connection between a source and a destination so that they can roam around and transmit robust communication. There are four major Ad-hoc routing protocols AODV, DSDV, DSR, and TORA.

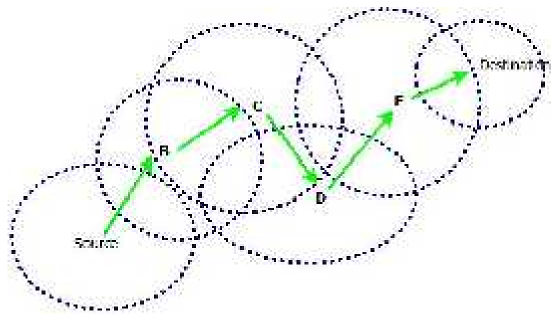

Fig. 1 Ad-hoc networking model.

In this paper, we first discuss two basic classes of selected routing protocols, one is reactive (DSR, AODV and TORA) and the other is proactive (DSDV). The combination of reactive and proactive routing protocols is referred to as hybrid class. After that we will assess the relative performance of these selected routing protocols with respect to selected performance metrics in different mobile ad-hoc network scenarios and to identify their performance challenges. In order to understand the effect of mobility on network we briefly mention and explain the characteristics of these protocols. Our main contribution to run simulations to evaluate the performance of different Ad-hoc routing protocols based on random waypoint mobility the results from the simulations.

Rest of paper is organized as, Section II briefly discussed the classification of MANET routing protocols and their functionality of the four familiar routing protocols (DSDV, AODV, TORA and DSR). Section III presents the simulation setup. Section IV presents simulation results and discussion of the above said routing protocols. Finally, Section V concludes with the comparisons of the overall performance of the four routing protocols based on different metrics.

II. ROUTING PROTOCOLS

Routing protocols can be broadly classified into two categories as (a) Table Driven (Proactive) Protocols and (b) On-Demand (Reactive) Protocols. In proactive protocols, each node maintains one or more tables containing routing information to every other node in the network. In this, tables need to be consistent and have to maintain up-to-date view of the network. Some of the existing table driven or proactive protocols are: DSDV [4], GSR [15], and ZRP [16]. In reactive protocols, routes are created on demand basis that is when it is desired by source node. When there is a transmission between sources to destination, a route is initiated by discovery process and Route is maintained until destination becomes unreachable, or source no longer is interested in destination. Some of the existing on demand routing protocols are: DSR [2][5][6], AODV [9][12], and TORA [13] [14].

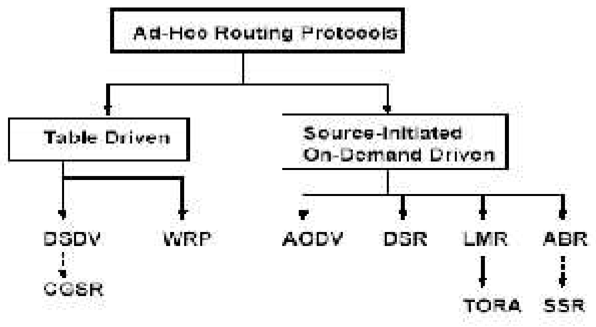

Fig. 2 Classification of Routing Protocols

A. Proactive Routing Protocols

A proactive (table driven) routing protocol maintains fresh lists of destinations and their routes by periodically distributing routing tables throughout the network. These protocols require each node to maintain one or more tables to store routing information, and they respond to changes in network topology by propagating updates routes through out the network in order to maintain a consistent network view. Their differences are responsible for the number of necessary routing related tables and the methods by which changes in network structure are broadcast There are several such type protocols as DSDV[4], DFR ("Direction" Forward Routing)[17], Guesswork: Robust Routing in an Uncertain World[18], Zone Routing Protocol (ZRP)[16], etc The main disadvantages of such algorithms are:

- Respective amount of data for maintenance.
- Slow reaction on restructuring and failures.

A.1 Destination-Sequenced Distance Vector Protocol

The Destination-Sequenced Distance-Vector Routing protocol (DSDV) described in [2] is a table-driven algorithm based on the classical Bellman-Ford routing mechanism [3]. The improvements made to the Bellman-Ford algorithm to solve the routing loop problem means freedom from loops in routing tables. Each node maintains a list of all destinations and number of hops to each destination. Each entry is marked with a sequence number assigned by the destination node. It uses full dump or incremental update to reduce network traffic generated by rout updates. The broadcast of route updates is delayed by settling time. Routing table updates are periodically transmitted throughout the network in order to maintain table regularity. To help improve the potentially large amount of network traffic that such updates can generate, route updates. The routing table contains information such as the address of the destination, the number of hops to reach the destination, the sequence number of the information received concerning the destination, as well as a new sequence number sole to the broadcast [2]. But the most recent sequenced number is used. In the event that two updates have the same sequence number, the route with the smaller metric is used in order to optimize (shorten) the path.

B. Reactive Routing Protocols

Reactive Ad-hoc routing protocols determine a path on-demand only flooding the network with Route Request packets, meaning that they search for a single path when a message needs to be delivered. This type of protocols finds a route on demand by. The main disadvantages of such algorithms are:

- High latency time in route finding.
- Excessive flooding can lead to network clogging.

Examples of reactive routing protocol are: ESAODV (Extra Secure Ad-hoc On Demand Vector), Ad-hoc On Demand Distance Vector (AODV) [12], the Dynamic Source Routing (DSR) [10] and the Temporally Ordered Routing Algorithm (TORA) [13] etc as the most widely used reactive Ad-hoc routing protocols.

B.1 Ad-hoc On-demand Distance Vector Routing

In Ad-hoc On Demand Distance Vector (AODV)[12], the originating node initiates a Route Request (RREQ) message that is flooded through the network to the destination. The intermediate nodes in the route record the RREQ message. A Route Reply (RREP), the acknowledgement message is sent back to the originating node as unicast following the reverse routes established by the received RREQ message. The intermediate nodes in the route also updated record by the RREP message in their routing table for future use. Each node keeps the most recently used route information in its cache. Therefore, AODV is a simple routing protocol and does not require excessive resources on the nodes. However, the routing information accessible in the nodes is limited, and the route discovery process may take too much time.

B.2 Dynamic Source Routing Protocol

The Dynamic Source Routing protocol (DSR)[2][7][10] is an efficient routing protocol designed particularly for use in multi-hop wireless ad-hoc networks of mobile nodes. DSR is a reactive routing protocol uses source routing to send packets. It uses source routing, means that the source must know the entire hop sequence to the destination. Each node maintains a route cache, where all routes it knows are stored. The route discovery process is initiated only if the desired route cannot be found in the route cache. The protocol is serene of the two main mechanisms of *Route Discovery* and *Route Maintenance*, which work jointly to allow nodes to discover and maintain routes to random destinations in the ad-hoc network. The protocol allows multiple routes to any destination and each sender to select and control the routes used in routing its packets.

B.3 Temporally Ordered Routing Algorithm

Temporally Ordered Routing Algorithm (TORA) [1][13] is highly adaptive distributed and attempts to achieve high degree of scalability, using a *flat*, non-hierarchical routing algorithm designed to operate in a highly dynamic mobile networking environment. TORA is based on the concept of *link reversal* possesses the attributes as distributed execution, multipath routing, loop-free routing, route establishment and maintenance, and minimization of communication overhead via localization of algorithmic reaction to topological changes and maintaining multiple routes to the destination. Shortest hop paths are given secondary importance and longer routes are often used to reduce the overhead of discovering newer routes. Thus, TORA fits under the stability category. In order to achieve this, the TORA does not use a shortest path solution, an approach which is unusual for routing algorithms of this type. The key design concepts of TORA [14] are localization of control messages to a very small set of nodes near the occurrence of a topological change. To accomplish this, nodes need to maintain the routing information about adjacent (one hop) nodes.

C. Proactive versus Reactive Approaches

Ad-hoc routing protocols may generally be categorized as being either proactive or on-demand (reactive) according to their routing strategy [22]. Proactive protocols attempt to maintain a correct view of the network topology all the time and build routes from each node to every other node before they are needed. These protocols require each node to maintain one or more tables to store routing information, hence they are also called table-driven protocols. Any changes in topology are propagated through the network, so that all nodes know of the changes in topology. There are obvious differences between proactive and reactive routing protocols, with both categories having their relative merits and drawbacks. It is likely, that no one protocol will meet all the constraints that have to be taken into consideration.

D. Performance Metrics

This paper had considered several metrics [11][20] for the performance analysis of routing protocols. These metrics are as follows:

- ***Routing overhead:*** The total number of control packets for the routing over the total number of data packets transmitted during the simulation. This reflects the degree of routing action, which is also occasionally characterized by the normalized routing load. If data traffic and control traffic share the same channel, and the channels capacity is limited, then extreme control traffic often impacts data routing performance.
- ***Path optimality:*** Ability to let one router pick the path it would have best ensured by all others, had it known all the paths available at the borders. The

difference between the number of hops a packet took to arrive at its destination and the length of the shortest path that actually existed through the network when the packet was originated.

- ***Throughput:*** It is defined as total number of packets received by the destination divided by the total duration of simulation time. It is a measure of effectiveness of a routing protocol. Finally, the throughput of each routing protocol in terms of the number of packets delivered successfully per second is evaluated.
- ***Packet delivery ratio:*** the ratio between the numbers of packets received by the TCP sink at the final destination and the number of packets sent by the sources. It is a measure of efficiency of the protocol.
- ***Packets lost:*** Packet lost is a measure of the number of packets dropped by the routers due to several reasons. The reasons we have considered for evaluation are collisions, looping, time outs, and errors.
- ***End to end delay:*** End to end delay refers the time taken for the data packet to reach from source to destination across a network.
- ***Pause time***: it refers the period of time for a node in pause when it reached at a destination and then another random destination is targeted.

E. Mobility Metrics

In this paper we used mobility is an important parameter in our simulation, referred to as mobility, intended to detain and quantify the kind of node motion relevant for wireless ad-hoc routing protocol[11][21]. We used a random waypoint mobility model, each node starts to a randomly chosen destination with a randomly chosen constant speed, when it reached destination, another random destination is targeted after the pause time. Therefore, pause time can be used only in a mobility model with nodal pause. Pause time is mobility metric that reflects for one node information. . This simple mobility metric is used only in random waypoint mobility model, but we cannot use any other mobility models. Mobile Ad-hoc protocols have to take action as soon as relative motion of nodes as a result links to split or form and mobility metric must as result be proportional to the number of such actions. The metric should be autonomous of the meticulous network technology used. Consequently mobility metric is anticipated which is arithmetical in the intelligence that the speed of a node in relative to other nodes is calculated, whereas it is autonomous of any links formed stuck between nodes in the network.

The performance of the routing protocols in wireless mobile Ad-hoc networks is very much influenced by the incidence of network topology changes due to mobility of nodes. Mobility information [21] of a node to convey node mobility contains a direction, speed, situation, pause time and a transmission range. The classification of the mobility metrics as categories in three type ***node, link, neighbors***. Category ***node*** focuses on a certain node, and uses its mobility information. Category ***link*** focuses on a certain link between two nodes and uses their mobility information. Category ***neighbors'*** focuses on the whole neighbors of a certain node and treats neighbor's mobility together.

The relationship between node mobility and the value of mobility metrics as shown in Table I, we get the large value of all these pause time, link expiration time, number of neighbor nodes, connectivity when takes mobility metric is low and whenever get smaller value of all these relative velocity, frequency of link state changes when takes mobility metric is high.

Table I: Relationship between node mobility and the value of mobility metric

Mobility metric	**Mobility**	
	Low	High
Pause time	High	Low
Relative velocity	Low	High
Link expiration time	High	Low
Number of neighbor nodes	High	Low
Connectivity	High	Low
Frequency of link state changes	Low	High

III.SIMULATION SETUP

The goal is to explore the performance of Ad-hoc networks under different routing protocols qualitatively in order to have a good understanding of the design tradeoffs of routing protocols. The limitation of measurements, on the other hand, is that generalizing the results is difficult. Anyway, our objective to improve on routing protocol design and justify design choices without having such a theory by using both measurements and simulations, by explaining the differences between the two approaches and thus verifying the work. This section, our simulation results justifying the advantages and drawbacks of the reactive and proactive Ad-hoc routing protocols will be presented [3]. The comparison of routing protocols has been done using ns-2 simulator version 2.34[8]. Ad-hoc networks will be deployed under different mobility patterns and the routing protocols have to perform in different environments. Therefore, the nodes in this simulation move according to a model that is called the "random waypoint" model. At beginning of simulation, every node weights for a pause time then randomly selects and moves to a destination, with speed randomly mendacious between zero and some maximum speed.

Table 1 Simulation Parameters

Parameters	Value
Simulation area	500m x 500m.
Simulation time	240 seconds
Number of nodes	50 nodes
Traffic sources	Constant Bit Rate (CBR)
Data packets size	512 bytes
Sending rate	8 packets/second
Maximum connection	10
Pause time between node movements	0, 40, 80, 120, 160, 200 and 240 seconds.
Maximum Speed	20m/s
Mobility model used	Random waypoint

The movement scenario files that are used for each simulation are characterized by a pause time. Each node begins the simulation by remaining stationary for pause time seconds. It then selects a random destination in the 500×500 rectangular area and moves to that destination at a speed distributed uniformly between 0 and some maximum speed (20m/sec). Upon reaching the destination, the node pauses again for pause time seconds, selects another destination, and proceeds there as previously described, repeating this behaviour for the duration of the simulation.

Our simulations reflect the performance of ad-hoc networks under different mobility conditions and using different routing and transport protocols. The simulations last for 240 seconds, thus a pause time of 240 seconds is equivalent to static nodes that do not move during the simulation and where as pause time 0 second corresponding to continuous motion of the nodes. Both reactive (i.e. AODV, TORA, DSR) and proactive routing protocols (i.e. DSDV) are covered in the simulations. The simulation results presented in this section are inaccurate due to the random behaviour of the nodes.

IV SIMULATION RESULTS AND ANALYSIS ON MOBILITY

This section discusses the simulation results for mobility; simulations reflect the performance of mobile ad-hoc networks under different mobility conditions and using different routing protocols. The simulations last for 240 seconds, thus a pause time of 240 seconds means that mobility of node is zero pointed to static nodes and where as pause time 0 second corresponding to continuous motion of the nodes. Both reactive and proactive routing protocols are covered in the simulations. Fig. 3 shows that routing overhead versus node mobility. The X-Axis represents the pause time in seconds and Y-Axis indicates the routing overhead in kilobytes. Proactive protocol (DSDV) have a higher routing overhead than reactive protocols (AODV, DSR, and TORA), due to additional topology information exchanged by them. Specially, AODV generates less routing overhead compared to TORA, DSR and DSDV in different pause times.

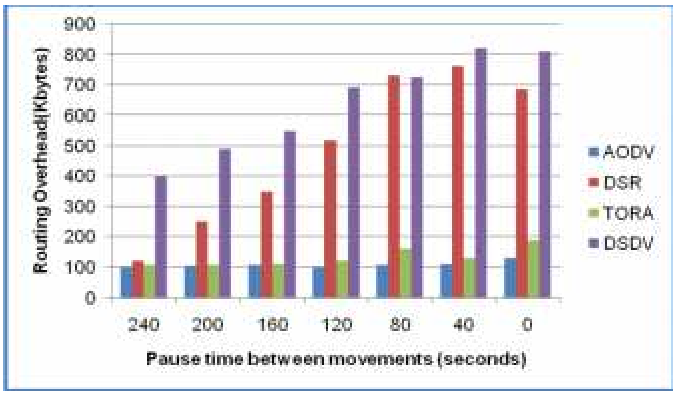

Fig. 3 Routing overhead versus node mobility.

Fig. 4 entail the performance of packet delivery fraction versus pause time, The X-axis represents the pause time in seconds and Y-axis indicates packet delivery fraction. DSDV shows very rapidly decreases packet delivery fraction on mobility increases. This is because DSDV protocol needs to maintains routing table and this routing table is to be broadcasted periodically and on-demand basis. At high mobility the both DSR and AODV routing protocols can deliver more than 86% of the sent packets. Whereas DSR and AODV behave well because of their reactive nature. Performance of TORA is better than DSDV.

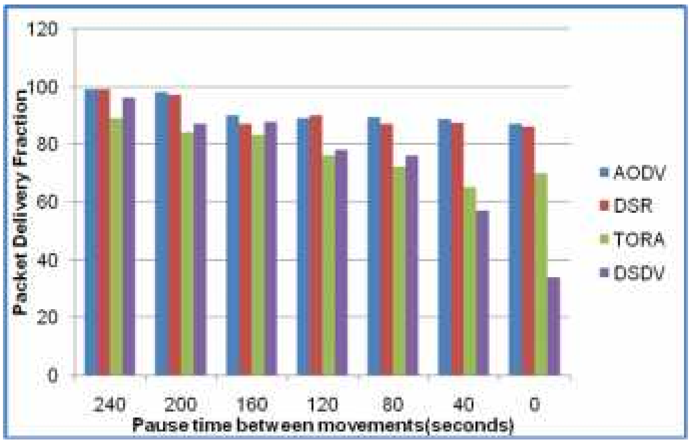

Fig. 4 Packet delivery fractions versus pause time

Fig. 5 entail the percentage of optimal routes versus pause time or nodes mobility. The X-axis represents the pause time in seconds and Y-axis indicates percentage of optimal routes. Performance of both proactive and reactive protocols decreases when mobility increases. But overall assessment; shows that proactive protocols perform better than reactive.

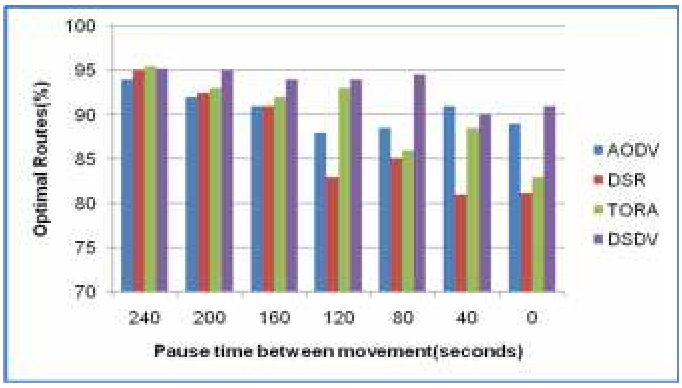

Fig. 5 Percentage of optimal routes versus node mobility.

Fig. 6 shows the percentage of packet loss versus node mobility. The X-axis represents the pause time in seconds and Y-axis indicates percentage of optimal routes. The percentage of packet loss in reactive protocols is less than in case of proactive routing protocols and it worst when mobility increases. The percentage of packets that did not reach the destination from the total number of packets sent has measured as packet loss.

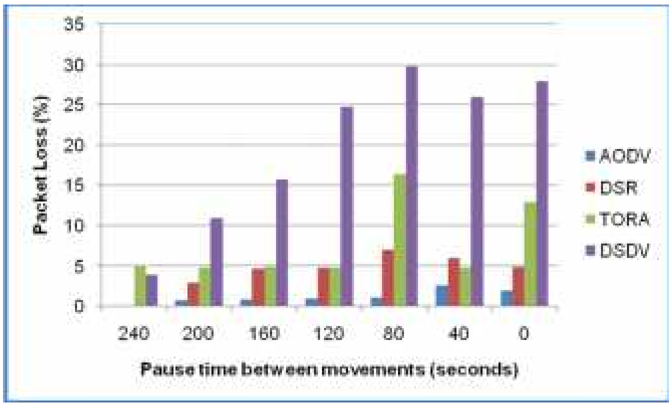

Fig. 6 Percentage of packet loss versus node mobility

Fig. 7 entails the end to end packet delay versus node mobility with UDP traffic flows. Proactive protocols DSDV shows the higher delay than reactive protocols. Reactive protocol DSR has higher delay than AODV than AODV and TORA. Overall all reactive and proactive protocols have increases end to end packet delay in case of mobility increases.

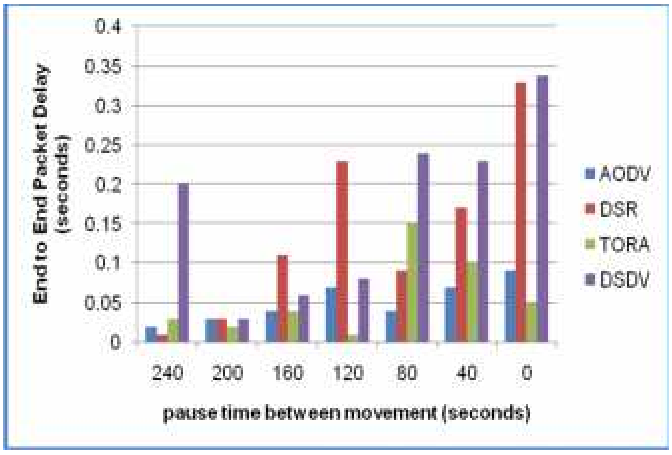

Fig. 7 End to end packet delay versus node mobility

Above simulation results shows that performance of proactive as well as reactive routing protocols have decreases in case mobility increases. TORA is highly adaptive, loop-free, distributed routing algorithm based on the concept of link reversal. As mobility increases packet delivery in TORA rapidly decreases in comparison with DSR and AODV because it uses inter-node coordination [13].

V. CONCLUSION

In this paper, Network Simulator NS-2 has been used for simulation work, we evaluated the performance of widely used Ad-hoc network routing protocols. The simulation characteristics used in this research as, packet delivery fraction, average end-to-end delay, mobility, optimal route, packet loss and routing overhead are very important for performance evaluation of any network routing protocol. Performance evaluation results for some Ad-hoc network protocols were previously reported [1], which primarily covered the control traffic received and sent, data traffic received, throughput, retransmission attempts, and traffic received. In this paper, we perform thorough analysis that includes additional parameters. For comparative performance analysis, we first simulated each protocol for Ad-hoc networks with 50 nodes. In case of mobility increases then routing overhead increases speedily in DSDV as well as DSR, but AODV and TORA better performs in high mobility. DSR and DSDV show poor performance as compared to TORA and AODV as result in Fig. 4. The percentage of packet loss is higher in case of proactive routing protocols than in case of reactive routing protocols and increases with mobility. The percentage of optimal routes decreases in both reactive and proactive protocols with node mobility increases. However reactive protocols perform better than proactive protocols. At high mobility, DSR and AODV can deliver more than 96% of the sent packets and TORA delivers less than DSR and AODV because it uses inter-nodal coordination. There are obvious differences between proactive and reactive routing protocols, with both categories having their relative merits and drawbacks, that is to say no one protocol will meet all the constraints that have to be taken into consideration.

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