Investigation on Power Awareness in $OSPF_{V2}$ and RIP_{V2} Routing Protocol in Wireless Sensor Networks

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Abstract: ***In a mobile ad hoc network, nodes are often powered by batteries. The power level of a battery is finite and limits the lifetime of a node. Every message sent and every computation performed drains the battery. One solution for power conservation in mobile ad hoc network is power awareness routing. This means that routing decisions made by the routing protocol should be based on the power-status of the nodes. Nodes with low batteries will be less preferably for forwarding packets than nodes with full batteries, thus increasing the life of the nodes. A routing protocol should try to minimize control traffic, such as periodic update messages to improve the lifetime of the nodes and network. However, not every routing protocol is suitable for implementing power awareness routing and different approaches on power awareness routing. In this paper we present Power Awareness Routing in $OSPF_{V2}$ and RIP_{V2} protocols using QualNet 5.0 simulator. Two different IGP based routing protocols are used for generating Link State Updates in $OSPF_{V2}$ and distance vector RIP_{V2} routing prototype. For effective performance of these routing protocols we also analyzed their comparison on the basis of measuring metrics like Average jitter, Average end to end delay, Packet Delivery ratio, Power consumed (mw) in transmit, received and ideal modes, using random mobility model, varying CBR traffic load and number of nodes can be used to create practical networks that emulate real network scenarios.***

Keywords: Ad hoc network, CBR, RIP_{V2}, $OSPF_{V2}$, Power Model, QualNet 5.0

1. Introduction

Currently, one of most innovative topics in computer communications is mobile wireless networking. Recent technological advancement in wireless data communication devices and laptops has lead to lower prices and higher data rates. This offers users new applications in mobile computing and has show the way to a rapid growth in the number of wireless networks [1]. Today, wireless networks (WLANs) can increasingly be found in office, education, and industrial environments. The concept of ad hoc networking in computer communications is that users wanting to communicate with each other form a temporary network, without any form of centralized administration. Each node participating in the network acts both as host and router and must therefore is willing to forward packets for other nodes. For this purpose, a routing protocol is needed.

Mobility, potentially very large number of mobile nodes, heterogeneity (terminals can have very different capabilities) and limited resources (like bandwidth and power) make routing in ad hoc networks extremely challenging. There are already several routing protocols developed for mobile ad hoc network what deal with these issues. In a mobile ad hoc network nodes are often powered by batteries. The power level of a battery is finite and limits the lifetime of a node. Every message sent and every computation performed drains the battery [2]. This means that the routing protocol should try to minimize control traffic, such as periodic update messages. To improve the lifetime of the nodes and network even further, one should also try to keep the data traffic as low as possible. This optimization can be achieved by utilizing power awareness routing. This means that routing decisions make by the routing protocol is based on the power-status of the nodes. Nodes with low batteries will be less preferably for forwarding packets than nodes with full batteries thus increasing the life of the nodes. However, not every routing protocol is suitable for implementing power awareness routing and different approaches on power awareness routing can be followed.

The main objectives of this paper are to study ad hoc networking and investigate the possibilities for power awareness routing in a mobile ad hoc network. Power consumption of a node can be divided according to functionality into [6] [7]:

The power utilized for the transmission of a message;
The power utilized for the reception of a message;
The power utilized while the system is idle.

We suggest two complementary levels at which power consumption can be optimized by control and management in wireless communication:

- Minimizing power consumption during the idle time by switching to sleep mode; this is known as Power Management [9];
- Minimizing power consumption during communication, that is, while the system is transmitting and receiving messages; this is known as Power Control [10].
- Compute a path that maximizes the minimal power consumption; that is, use the path that requires the least power to transmit and receive a message [13].
- Compute a path that maximizes the minimal residual power in the network; that is, use a path according to the residual energy of the nodes [13].

Obviously, both of these can not be optimized at the same time, which means there is a tradeoff between these. In the beginning when all the nodes have plenty of energy, the minimum total consumed energy path is better off, whereas towards the end avoiding the small residual energy node becomes more important. Ideally, the link cost function should be such that when the nodes have plenty of residual energy, the power consumption term should be applied, while if the residual energy of a node becomes small the residual energy term should be applied [4]. We design and build a multihop ad hoc network test bed, hereby implementing power awareness into an existing implementation of the $OSPF_{V2}$ (Open Shortest Path) and RIP_{V2} routing protocol [3][5].

The rest of the paper is organized as follows. Sections 2 problem formulation and major issues. Section 3 gives the details of $OSPF_{V2}$ and RIP_{V2} routing protocol. Section 4 gives simulation setup and energy model. Simulations and results are shown in section 5. Sections 6 describe our conclusion and future work.

2. Problem Formulation and Major Issues

One of the main objectives of this paper is to investigate power awareness routing in a wireless IEEE 802.11b ad hoc network [8]. The key issue with ad-hoc networking is how to send a message from one node to another with no direct link. The nodes in the network are moving around randomly, and it is very difficult that which nodes are directly linked together and the intermediate node judges its ability to forward the RREQ packets or drop it. The number of packets transferred successfully by each node. Route from source to destination is determined by selecting the most trusted path. Here battery capacity is not considered as an issue for selecting the path between source and destination. Same time topology of the network is constantly changing and it is very difficult for routing process. We efforts to simulate and analyze of these two parameters to discover a reliable power aware route between the source and destination and reduce power consumption.

3. Power Aware based $OSPF_{v2}$ and RIP_{v2} Routing Protocols

A routing protocol is needed whenever a packet needs to be transmitted source to destination via number of nodes and numerous routing protocols. Basically, routing protocols can be broadly classified into three types as [4]:

1. Table -driven (or) proactive routing protocol
2. On-demand (or) reactive routing protocol
3. Hybrid routing protocol.

Table Driven Routing Protocols: Every node maintains the network topology information in the form of routing tables by periodically exchanging routing information. Examples are DSDV, WRP, CGSR, OLSR, STAR, FSR, HSR, and GSR [15].

On Demand Routing Protocols: These Protocols do not maintain the network topology information. They obtain the necessary path when it is required, by using a connection establishment process. Examples are DSR, AODV, TORA, ABR, SSA, FORP, and PLBR.

Hybrid Routing Protocols: Protocols belonging to this category combine the best features of table driven and on demand routing protocols. Protocols in this category are CEDAR, ZRP, and ZHLS [15].

3.1 $OSPF_{v2}$ and RIP_{v2} Routing Protocols under Consideration for Power awareness

3.1.1 Overview of Open Shortest Path First $_{version\ 2}$ ($OSPF_{V2}$)

The Open Shortest Path First$_{version2}$ ($OSPF_{V2}$) protocol is a link-state Interior Gateway Protocols (IGP) originally designed to compete with RIP_{V2}. It requires each $OSPF_{V2}$ router to maintain a database of internal topology of the AS domain [12] [15]. From this database, routing table is obtained by performing SPF algorithm (Dijkstra's Algorithm) and by constructing a shortest-path tree. $OSPF_{V2}$ is designed to provide quick convergence with only a small amount of routing control traffic, even in autonomous systems (ASs) with a large number of routers. As a link state protocol, the core of $OSPF_{V2}$ consists of creating and maintaining a distributed replicated database (called the link-state database). Each $OSPF_{V2}$ router originates one or more link-state advertisements (LSAs) to describe its local part of the routing domain. Taken together, the LSAs form the link-state database, which is used as input to the routing calculations.

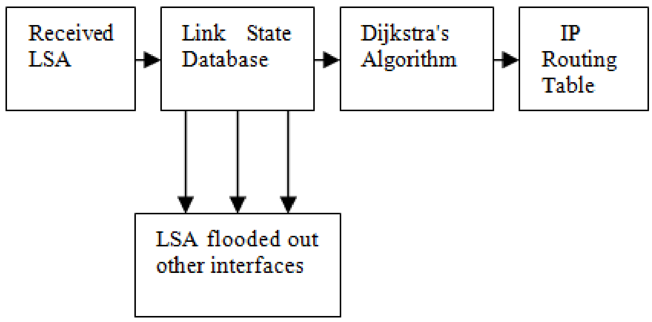

Figure 1: Shows schematically how $OSPF_{V2}$ operates.

Fig. 1 Fig shows operation of the $OSPF_{V2}$ protocol. $OSPF_{V2}$ LSAs received on one interface are installed in the link-state database and flooded out the router's other interfaces. From the link-state database, an $OSPF_{V2}$ router calculates its routing table, using Dijkstra's Shortest Path First (SPF) algorithm.

Link-State Algorithm:

$OSPF_{V2}$ is a link state protocol, which means that routing decisions are made based on the status of the connections (links) between the routers in the network. The link-state algorithm forms the foundation of the $OSPF_{v2}$ protocol. This algorithm is used by $OSPF_{V2}$ to build and calculate the shortest path to all known destinations [12].

Shortest Path Algorithm:

The shortest path is calculated using the Dijkstra algorithm. The algorithm places each router at the root of a tree and calculates the shortest path along the actual links of the network to each destination. ***Areas and Border Routers:***

$OSPF_{V2}$ uses flooding to exchange Link State Updates between routers. Any change in routing information is flooded to all routers in the network. To limit the number of Link State Updates and to put a boundary on the explosion of Link State Updates in an $OSPF_{V2}$ domain a routing hierarchy can be implemented. The routing domain can be divided into regions called $OSPF_{V2}$ areas. Flooding and calculation of the Dijkstra algorithm on a router is limited to changes within an area. All routers within an area have the exact link-state database. A router that has all of its interfaces within the same area is called an internal router (IR) [12].

$OSPF_{V2}$ Routing Protocol Packets:

The $OSPF_{V2}$ protocol runs directly over IP and fragmentation is used. $OSPF_{V2}$ protocol packets have been designed so that large protocol packets can generally be split into several smaller protocol packets.

Table 1: The OSPFV2 packet types are listed below:

	Type Packet name	***Protocol function***
1	Hello Packets Sent / Received	Number of Hello packets sent and received by nodes.
2	Link State Update Packets Sent / Received	Number of Link State Update packets sent/received by nodes.
3	Link State Update Packets Sent / Received	Number of Link State Update packets sent/received by nodes.
4	Link State ACK Packets Sent/Received	Number of Acknowledge packets sent / received by nodes.
5	Link State Request Packets Sent/ Received	Number of Link State Request packets sent/received by a node.
6	Network LSA Originated	Number of network LSA originated by a node.
7	Number of LSA Refreshed	Number of LSA refreshed by a node.

3.1.2 Overview of Routing Information Protocol Version 2 (RIPV2)

The oldest distance vector protocol is still in utilized: RIP (Routing Information Protocol) exists in two versions. This work is based in the newest version, which is RIP_{V2}. RIP_{V2} is internet standard implementations of the Bellman-Ford routing algorithm. Routing Information Protocol (RIP) is an Interior Gateway Protocol (IGP) used to exchange routing information within a domain or autonomous system. RIP_{V2} lets routers exchange information about destinations for the purpose of computing routes throughout the network. Destinations may be individual hosts, networks, or special destinations used to convey a default route. RIP_{V2} does not alter IP packets; it routes them based on destination address only. It is a distance vector routing algorithm using the User Datagram Protocol (UDP) protocol for control packet transmission [11].

3.2 Comparison between distance vector and link state protocols

The main difference between distance vector and link state protocols is the algorithm in which they are based. A distance vector protocol learns routes and sends them to directly connected neighbors. By contrast, link state protocols advertise the state of all links (through packages known as LSAs) that participate in the routing process, so that the other routers in the area can build the topology database [11] [12].

Table 2: Differences between distance vector and link state protocols are summarized;

	RIP_{V2} (DISTANCE VECTOR)	*$OSPF_{V2}$ (LINK STATE)*
Algorithm	Bellman-Ford	Dijsktra
Network view	Topology knowledge from the neighbour point of view	Common and complete knowledge of the N/W topology
Best Path Calculation	Based on the fewest number of hops	Based on the cost (hops, BW, delay...)
Updates	Full routing table	Link State Updates
Updates Frequency	Frequently periodic updates	Triggered updates
Routing Loops	Needs additional procedures to avoid them	By construction, routing loops cannot happened
CPU and Memory	Low utilization	Intensive
Simplicity	High simplicity	Requires a trained network administrator

4. Simulation Setup and Models

We have used a simulation model based on QualNet 5.0 Simulator, with Graphical User Interface tools for performance analysis comparison [14] [16]. The simulator contains standard API for composition of protocols across different layers. The simulation parameters for design a scenario for power aware are given below in Table 1. The scenario is designed for power aware routing protocol using $OSPF_{V2}$ and RIP_{V2} protocols, after running the scenario program snapshot is obtained shown in figure 3.

Table 3: Power and Mobility traffic model parameters for $OSPF_{V2}$ and RIP_{v2} routing protocol

Parameters	***Values***
Simulator	QUALNET 5.0
Routing Protocols	$OSPF_{V2}$ and RIP_{V2}
Mac Type	IEEE 802.11
Number of Nodes	80
Variation of Nodes	10 equal numbers
Transmission range	300m
Simulation Area	1500*1500
Mobility Model	Random Waypoint Mobility
Energy Model	Mica-Motes
Traffic Type	Constant-Bit Rate
Battery Model	Linear Model
Full Battery Capacity	1200 (mA,h)
Performance Matrices in Physical Layer	Energy consumed (in mjules) in transmit mode Energy consumed (in mjules) in received mode Energy Consumed (in mjules) in ideal mode
Energy Supply Voltage	6.5 Volt
Transmit Circuitry Power Consumption	100.0 mW

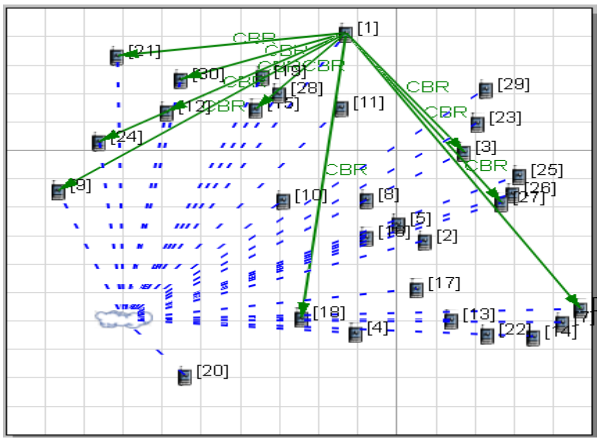

Figure 2: Snapshot of designed scenario for $OSPF_{V2}$ and RIP_{V2} for showing random nodes with CBR

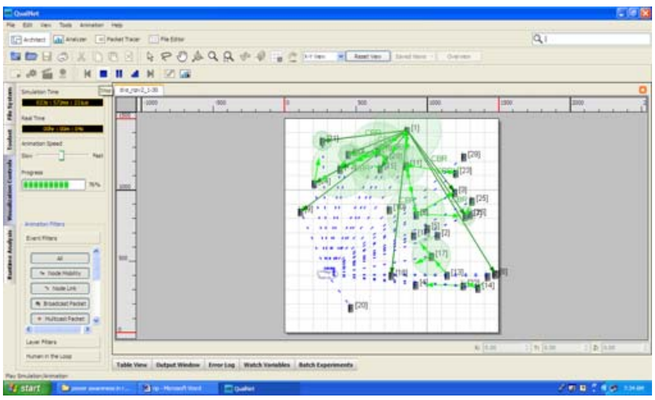

Figure 3: Snapshot of running designed scenario for $OSPF_{V2}$ routing protocol with numbers of CBR and nodes.

3.3 Performance Metrics

Now we are conducted extensive calculation on metrics based on terrain size. If terrain size varies; then corresponding metrics are rapidly changes while numbers of nodes are fixed. Here we perform thorough experimental scenarios are simulated in QualNet simulator to generate graphs in terms of metrics. The following metrics are studied and applied to current scenarios as shown in table 1 and figure 2 and 3.

5. Simulations and results

A. Average jitter

The jitter variation is the variation in time taken for packet to reach its destination, computed as:

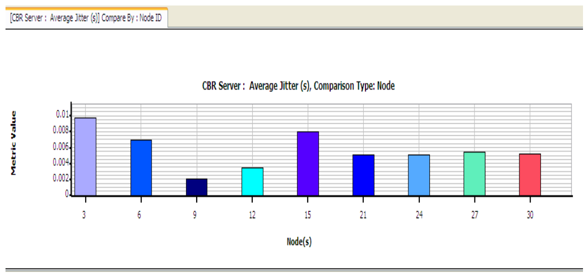

Figure 4: Snapshot of designed scenario output Average Jitter for $OSPF_{V2}$ routing protocol with numbers of CBR and nodes.

In terms of delay variation, we have observed that RIP_{V2} have lower jitter than $OSPF_{V2}$ due to the complex operations that $OSPF_{V2}$ has to carry out.

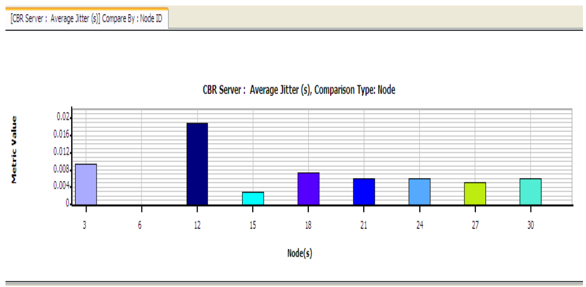

Figure 5: Snapshot of designed scenario output Average Jitter for RIP_{v2} routing protocol with numbers of CBR and nodes

Figure 4 and 5 demonstrate impact of varying offered load and size on jitter. Here, again RIP_{V2} comes up as best performer from $OSPF_{V2}$ protocol. As we can observe that after scaling network up to 30 nodes, instant rise in jitter for both protocols. This is due to that fact that as network size increases so is control overhead of Query messages, consumes more time to reconfigure the route.

B. Average end to end delay:

The delay is the time taken for the packet to reach its destination, in seconds, measured as the difference between the time a packet arrives at its destination and the creation time of the packet.

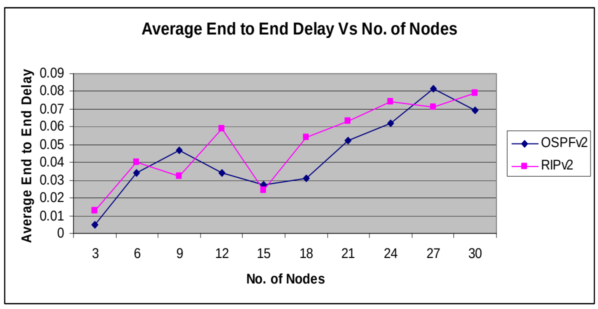

Figure 6: Comparison of average end to end delay with varying nodes at $OSPF_{V2}$ and RIP_{V2} routing protocols

Figure 6 illustrates average end to end delay by varying number of nodes and traffic sources. Simulation result demonstrates end to end delay remains negligible for small number of nodes. Nodes rises to 15, it drives significant increase in delay, even increase of CBR sources not help out.

C. Packet Delivery Ratio:

The ratio between the amount of incoming data packets and actually received data packets.

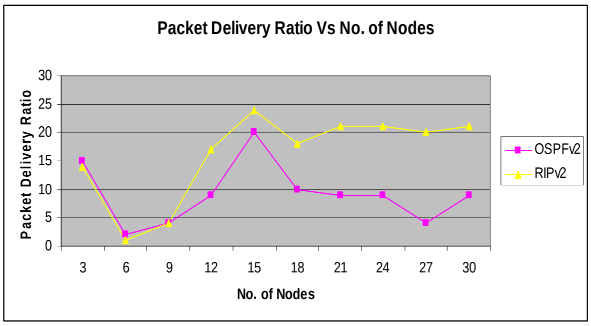

Figure 7: Comparison of packet delivery ratio with varying nodes at $OSPF_{V2}$ and RIP_{V2} routing protocols.

Figure 7 demonstrate packet delivery ratio by varying number of nodes and data packets. Simulation result shows that deliver of packets remains same for small number of nodes. Nodes rises to 15, it drives significant increase in packet delivery ratio. RIP_{V2} performs better than $OSPF_{V2}$.

D. Power consumed (mw) in Transmit Mode

Figure 8 illustrate power consumption in transmit mode by varying number of nodes and consumed power. Simulation result shows that $OSPF_{V2}$ consumes more power compare $RIP_{V2.}$ Power consumption for both protocols remains same for less number of nodes. When nodes rise to 21, it drives large increase in power consumption. RIP_{V2} consumes less power in transmit mode when compare to $OSPF_{V2}$.

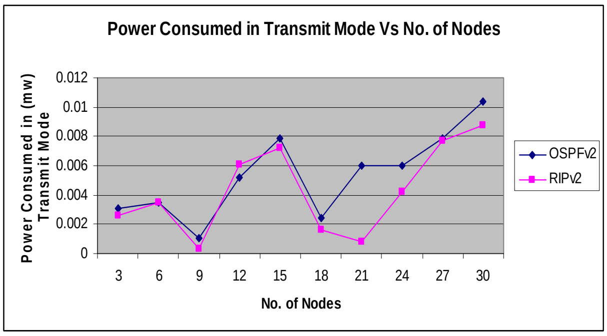

Figure 8: Power consumed in transmit mode with varying nodes $OSPF_{V2}$ and RIP_{V2} routing protocols.

E. Power consumed (mw) in Received Mode:

Figure 9 illustrate power consumption in receive mode by varying number of nodes and consumed power in receive mode. Simulation result shows that $OSPF_{V2}$ consumes more power in receive mode compare to $RIP_{V2.}$

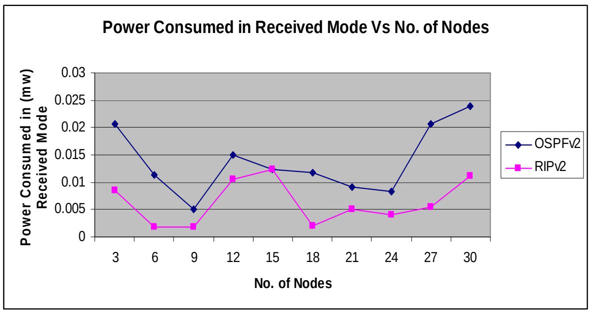

Figure 9: Power consumed in receive mode with varying nodes $OSPF_{V2}$ and RIP_{V2} routing protocols.

F. Power consumed (mw) in Ideal Mode:

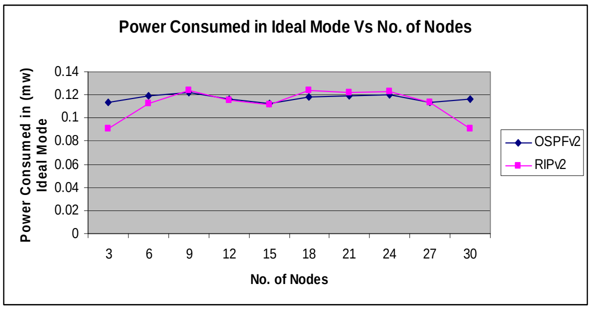

Figure 10: Power consumed in transmit mode with varying nodes $OSPF_{V2}$ and RIP_{V2} routing protocols.

Figure 10 illustrate power consumption in ideal mode with varying number of nodes and consumed power in ideal mode. Simulation result shows that $OSPF_{V2}$ consumes more power in ideal mode compare to $RIP_{V2.}$Power consumption almost same between 6 to 27 nodes.

Table 4: shows a summarization of the main analyzed attributes of each protocol.

	RIP_{V2}	***$OSPF_{V2}$***
Convergence	Slow	Fast
Link utilization	Inefficient	Optimal
Metric	Hop count	Cost based on BW
CPU Utilization	Optimal	Inefficient
Average End to End Delay	Increase when increases number of nodes.	Varies simultaneously with higher range of nodes.
Average Jitter	Lower	Higher
Load balancing	No	No
Topology change Updates	Periodic Updates	LSA flooding, adjacencies formed after three-way hand shaking
Power consumed (mw) in Transmit Mode	Remain same for less no of nodes.	More at higher nodes.
Power consumed (mw) in Received Mode	less	more
Energy consumed (mw) in Ideal Mode	Less as compare to $OPSF_{V2}$	Same as RIP_{V2}, but increases when nodes increases

6. Conclusion

The simulations have exposed the major constraints of RIP_{V2} routing protocol over $OSPF_{V2}$. However, the great advantage of this protocol is its simplicity of configuration and its lower processing consumption. The link state protocols need improvement in some of performance metric compare to distance vector protocols. We effort to try minimizing power consumption during the idle time by switching to sleep mode, minimize the efficient in finding a new route to increase the life time of the network. The data collected by simulation is very much needful to researcher shown in table 4. Our future work will highlight the mobility issues on reliability and power management in $OSPF_{V2}$ and RIP_{V2} routing protocols.

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