Throughput Evaluation of a Mobile Large-Scale Mesh Network Using a batman-adv with ns-3

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Abstract: How good would it feel to climb a mountain with my research grant? From Narita Airport via Suvarnabhumi International Airport, we landed at Tribhuvan International Airport. The next day, take a domestic flight to Tenzing-Hillary Airport (formerly Lukla Airport) and walk Everest Road. Or you could start from the Sea of Japan in Toyama Prefecture, traverse the Northern Alps, and reach the Pacific Ocean in Shizuoka Prefecture via the Central and Southern Alps. So, how can we climb mountains with a research grant? Mountains are a treasure trove of research materials. So, let's try it in an experiment to evaluate the effective throughput of a mobile large-scale meshwork constructed by combining MANET and ns-3.

1. The Beginning

`Gentlemen, I like mountains.`
`Gentlemen, I like mountains.`
`Gentlemen, I love mountains.`
[*1]

Obtaining competitive research funding and promoting RD, and making one's life worth living is both important and difficult to reconcile for a certain number of researchers. One common thing to all humans on Earth is that our rotation period is 23 hours, 56 minutes, and 4 seconds, and our orbital period is 365.244 days. two. One way to mitigate these difficulties in balancing the two is to match the value of one's life with research and development. For example, those who define their life's value as acquiring wealth and prestige will be able to achieve efficient compatibility if their research brings them wealth and prestige. Another means is to choose the value of one's life as the subject of one's research. For a certain number ($n > 0$) of researchers, it is mountain climbing.

Not only the mountains but the great outdoors is wonderful. When I (the author) see an overwhelming wilderness spread out before me, I (the author) am made keenly aware that the activities of a single human being are indeed very small. In the face of the overwhelming mass of nature, I realize that all life is equally meaningless and worthless. No, it is not. It is nonsense to find meaning and value in it. This is the esprit de corps of the nested structure of finding sense in being nonsense. Let me put this aside for a moment. Not only in Japan but in various regions of the world, cultures and customs have been nurtured that regard mountain, which are huge natural formations, as objects of religious awe. In Japan, mountainous areas, including hills, cover 75% of the country's land. Therefore, mountains have been revered as objects of religious worship in many parts of Japan. In Japan, a religion called Fuji-Kou was established in the Edo period (1603-1867). This is an exciting example of how mountain climbing was established as a religion.

Until the Edo period, climbing high mountains in Japan was a form of ascetic training for religious ascetics. In the aforementioned Fuji-kou, the actual climbers were able-bodied men with well-selected mountaineering skills. In the Meiji era (1868-1912), Western culture entered Japan. Mountaineering was one of these cultural influences. Highly developed mountaineering techniques brought safety to mountain climbing. As Japan opened its borders to the outside world, it became necessary to strengthen its military (wealthy country, strong military), and the spread of surveying and cold-resistant training by the military contributed to the development of mountaineering techniques. The appeal of mountaineering, which until then had been a deadly pursuit reserved for ascetic and religious practitioners, thus became a commodity. This was the dawn of mountaineering as a leisure activity. However, along with the long period of warfare from the Sino-Japanese War to World War II and the Pacific War, leisure mountaineering in Japan declined.

After the war, Japan was marked by the activities in other countries by city people who were trying to recover from the defeat. Mountaineering was no exception, and the first ascent of Manaslu in Nepal (the world's 8th highest peak, 8163 meters above sea level) by Toshio Imanishi and others in 1956 brought bright news to postwar Japan. This was the first of what is said to be three mountaineering booms in Japan since the beginning of time. It was also around this

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[*1] From Kouta Hirano "Hellsing" (1997-2008)

time (1959) that “Japan’s Hundred Famous Mountains,” a collection of mountain essays by Kyuuya Fukada, considered a sacred text for Japanese mountaineering enthusiasts, was published. The second boom in mountaineering is said to have occurred in 1994, a somewhat long time after the publication of the aforementioned “100 Famous Japanese Mountains”. Some believe that the third mountaineering boom, which began in 2007, was created by the mass media in the same way as the second mountaineering boom. However, the rise of mountaineering apparel companies such as THE NORTH FACE and Montbell in Japan is a factor that cannot be overlooked.

Now, let me continue with the preface. Internet connectivity in these mountainous regions has a long history of poor performance. The dominant telecommunications infrastructure supporting Internet connectivity in the underpopulated and mountainous areas is the 4G networks provided by mobile carrier companies. Strictly speaking, only LTE-Advanced and WiMAX2 are 4G projects that meet the criteria for IMT-Advanced as defined by the ITU, but in 2010 the ITU decided that LTE, WiMAX, and HSPA+ could also be called 4G. In response, domestic mobile carriers began to offer 4G services in the early 2010s. According to the Ministry of Internal Affairs and Communications “Summary of Evaluation Results of the 2021 Mobile Phone and Nationwide BWA Radio Wave Usage Survey” (2022), the population coverage rate of 4G services by the three mobile carriers companies all reached 95% or more. In addition, each company’s “actual population coverage,” based on its own standards, for example, au claims to have exceeded 99% as of 2013. On the other hand, area coverage will be below 50% for all carriers by 2021. This is because 75% of Japan’s land area is mountainous, including hilly areas. Since most of the country’s land area is not expected to be profitable for 4G base stations, improving area coverage is not a positive incentive for mobile carrier companies.

Another proposed approach to providing Internet connectivity in mountainous areas is not a 4G network but an airborne platform for communication using aircraft such as stratospheric airships and solar planes. 2011 saw Project Loon send 30 large balloons about 20 km below the earth’s surface. In 2019, Softbank Corp. launched a stratospheric communication platform project called HAPS mobile. platform project. However, Aquila ended its project in 2019; Project Loon was also disbanded in 2021 as it had fulfilled its role. The provision of Internet connectivity by stratospheric flying objects has failed to cross the uncanny valley to commercialization due to the following problems

- The need to rely on solar light to provide a large amount of power is needed to provide radio waves that reach the earth’s surface.
- CLOUD AVOIDANCE not only changes radio wave conditions depending on weather conditions but also makes it challenging to control stratospheric flying objects.
- high cost per unit, requiring patrols by multiple units to extend coverage and provide continuous service.

Can’t we do something about this through technology? Since ancient times, Japan has been known to have a research subject called “elephant eggs” as a sample application for a Grant-in-Aid for Scientific Research (KAKENHI). The story goes that a researcher who has had poor results in his search for whale eggs applies for a new research grant in the hope that elephant eggs might be found. I (the author) am not alone in my desire to satisfy my curiosity with research funds and to travel to Antarctica or Africa, as the case may be. Therefore, let’s try it and climb mountains with research funds. Let’s go on a trip to climb famous peaks around the world. We will have to try, and yes, it will be a great scientific experiment.

2. Technical Background

2.1 MANET

That’s where mobile (or wireless) ad-hoc network (MANET) comes in. MANET is a type of distributed wireless network. Ad hoc networking is a mode of communication in which nodes communicate with each other to transport data to nodes close to a base station, rather than the model of mobile carrier networks in which all clients (nodes) for wireless connectivity are connected to a base station. In particular, “wireless” ad hoc networks are self-configuring dynamic networks in which clients can move freely. Such wireless networks do not have the complexity of infrastructure setup and management, allowing devices to create and join networks ”on the fly”.

Each device in a MANET is free to move independently in any direction and will frequently change links with other devices. Each device is a router because it needs to forward traffic unrelated to its own use; the biggest challenge in building a MANET is equipping each device to maintain the information it needs to forward traffic continuously and properly. This is due to 1) the desire to route packets to all other nodes, 2) the percentage of overhead traffic required to maintain real-time routing conditions, 3) each node having its own goodput that routes independently without being aware of other needs, and 4) all being radio slices of spectrum, etc., must share limited communication bandwidth, which becomes difficult as the size of the MANET increases. Such networks may operate independently or be connected to the larger Internet. There can be one or multiple transceivers between nodes. The result is a highly dynamic and autonomous topology; MANETs typically have a routable networking environment on top of a link-layer ad hoc network.

2.2 OLSR

The Optimized Link State Routing Protocol (OLSR) is described in RFC 3626; OLSR is an IP routing protocol optimized for mobile ad hoc networks and can also be used in other wireless ad hoc networks. OLSR is a proactive link-state routing protocol that uses Hello and Topology Control (TC) messages to discover and disseminate link-state information throughout the mobile ad hoc network. Individual nodes use this topology information to calculate the next-hop destination for all nodes in the network using the shortest hop forwarding path.

Link-state routing protocols such as Open Shortest Path First (OSPF) and Intermediate System to Intermediate System (ISIS) elect a designated router for each link to flood topology information The router is then flooded with topology information. In wireless ad hoc networks, the concept of links is different, and packets may leave the same interface, requiring different approaches to optimize the flooding process; the OLSR protocol uses Hello messages to allow each node to discover two-hop adjacencies Multipoint Relay (MPR) distributed election. A node elects an MPR to have a path to each of its 2-hop neighbors via the node selected as the MPR. This MPR node sends and forwards the TC message, including the MPR selector. This MPR feature makes OLSR different from other link-state routing protocols in several ways: because of the MPR feature, OLSR differs from other link-state routing protocols in that the forwarding path of the TC message is not shared by all nodes, but rather, different senders and only some nodes send link state information and only those indicating MPR selection are advertised, rather than all links of a node.

Since link-state routing requires topology databases to be synchronized in the network, OSPF and IS-IS use reliable algorithms for topology flooding. Since such algorithms are very difficult in ad hoc wireless networks, OLSR does not care about reliability and simply floods the topology data often enough to keep the databases out of sync for long periods of time.MPR (Multipoint Relay) is a method of internode message relay of messages between nodes. It also plays a significant role in routing, selecting the appropriate route from any source to any desired destination node; the MPR periodically advertises link state information for its MPR selector (the node selected as the MPR) in control messages. MPRs are also used in route calculations to form a route from any node to any destination. Each node periodically broadcasts a Hello message for link sensing, adjacency detection, and MPR selection processes.

2.2.1 Advantages of OLSR

Being a proactive protocol, routes to all destinations in the network can be known and maintained before use. The availability of routes in a standard routing table is useful for some systems and network applications because there is no route discovery delay associated with finding new routes. The routing overhead generated is generally greater than for reactive protocols but does not increase with the number of routes created. Default and network routes can be injected into the system via HNA messages to allow connections to the Internet and other networks in the OLSR MANET cloud. Network routes are those that reactive protocols are currently unable to execute successfully. Timeout values and validity information are included in the informative messages, and different timer values can be used for different nodes.

2.2.2 Critique for OLSR

In the original definition of OLSR, there is no provision for sensing link quality. It assumes that if the number of recently received hello packets is high, the link is up. This assumes that the link is bimodal (working or failing), which is not always the case in wireless networks, where links often exhibit intermediate rates of packet loss. Implementations such as the open source OLSRd (often used in Linux-based mesh routers) have been extended (as of v.0.4.8) with link quality sensing. OLSR uses power and network resources to propagate data about potentially unused routes as a proactive protocol. This is fine for wired access points and laptops, but OLSR is not suitable for sensor networks that try to sleep most of the time; for small wired access points with low CPU power, the open-source OLSRd project has been working on 200 MHz It has shown that OLSRd can run large mesh networks with thousands of nodes with very little CPU power on embedded devices.

OLSR, a link-state protocol, requires a reasonably large amount of bandwidth and CPU power to compute the optimal paths in the network; in a typical network where OLSR is used (rarely more than a few hundred nodes), this does not seem to be a problem. By simply using MPR for flooding topology information, OLSR removes some of the redundancy in the flooding process. This may be a problem in networks with moderate to large packet loss rates.

2.3 B.A.T.M.A.N.

Better Approach to Mobile Ad-hoc Networking (B.A.T.M.A.N) is a routing protocol for multi-hop MANET under development by the German "Freifunk" community and is a replacement for Optimized Link State Routing Protocol (OLSR).

The key aspect of B.A.T.M.A.N. is its decentralized design, in which no single node has all the data, by decentralizing knowledge about the optimal route through the network. This technology eliminates the need to distribute information about network changes to all nodes in the network. Individual nodes store only information about the "direction" in which they receive data and transmit data accordingly. Data is passed from node to node, and packets get individually and dynamically created routes. A network of collective knowledge is created. in early 2007, the developers of B.A.T.M.A.N. began experimenting with routing at Layer 2 (the Ethernet layer) rather than Layer 3. The suffix "adv" (for: advanced) was chosen to distinguish it from the Layer 3 routing daemon: instead of manipulating the routing table based on the information exchanged over UDP/IP, it provides a virtual network interface that itself transparently forwards Ethernet packets. The batman-adv kernel module has been included in the official Linux kernel since 2.6.38.

2.4 ns (ns-3)

ns (from network simulator) is a name for a series of discrete event network simulators, specifically ns-1, ns-2, and ns-3. All are discrete-event computer network simulators, primarily used in research[3] and teaching. The first version of ns, known as ns-1, was developed at Lawrence Berkeley National Laboratory (LBNL) in the 1995-97 timeframe by Steve McCanne, Sally Floyd, Kevin Fall, and other contributors. This was known as the LBNL Network Simulator and was derived in 1989 from an earlier simulator known as REAL by S. Keshav. Ns-2 began as a revision of ns-1. From 1997 to 2000, ns development was supported by DARPA through the VINT project at LBL, Xerox PARC, UCB, and USC/ISI. In 2000, ns-2 development was supported through DARPA with SAMAN and through NSF with CONSER, both at USC/ISI, in collaboration with other researchers, including ACIRI.

In 2003, a team led by Tom Henderson, George Riley, Sally Floyd, and Sumit Roy applied for and received funding from the U.S. National Science Foundation (NSF) to build a replacement for ns-2 and ns-3. This team collaborated with the Planete project of INRIA at Sophia Antipolis, with Mathieu Lacage as the software lead, and formed a new open source project. In the process of developing ns-3, it was decided to abandon backward compatibility with ns-2 completely. The new simulator would be written using the C++ programming language from scratch. Development of ns-3 began in July 2006.

3. Methodology

When the number of nodes is on the order of 10, 100, 1000, or even 10,000, what level of TCP throughput can be expected from a WLAN client at an arbitrary location if the nodes are stationary in the two-dimensional plane? Starting with a model of a very small mesh network, we will conduct evaluation experiments using ns-3.

For example, in an even lattice obtained by dividing a square, consider that these nodes are located at each node of the lattice. Next, let one of any two adjacent points be the starting point and the other the endpoint. The path from the start point to the endpoint is created by passing through all nodes in a single stroke, and the nodes at each node are assumed to continue moving along this path. When a node arrives at the endpoint, it moves to the start point. In the real world, a node is an access point, and since it is equipped with some kind of mobile device, it is a mobile or a portable access point. The portable access point that reaches the endpoint has a depleted battery in the real world, so it performs the recharging operation here. Other access points are assumed to be in non-electrified areas with no power supply. Using such a model, the area within this square can always be kept within the access range of the wireless LAN.

In this case, how should each access point link its WLAN to neighboring access points? We wanted to conduct an evaluation experiment by trying various algorithms (including existing ones) and confirming their effectiveness through throughput measurements. However, I was enjoying the summer too much and could not reach that point at the time of the deadline of this report. I have written this paper to leave a footprint on the first step we have taken. Like a mountain climbing.

4. Conclusion

At the time of this writing, we have already been able to obtain a budget for mountain climbing and have actually executed that budget for mountain climbing. The target of the budget was Mt. Asama (Nagano and Gunma prefecture, 2,568 m), but at that time the eruption alert level was 2, which meant that not only the highest point, but even Maekakeyama, the inner of the characteristic two-tiered outer rim of the mountain. I was only able to climb the outer rim of the mountain. Therefore, the future tasks are to climb Maekakeyama, the inner rim of it. And I will try to climb Mt. Fuji from an elevation of 0 m. As a preliminary training, we plan to do a weekly round trip of the Rokko traverse (to Takarazuka Station) starting from Sumaura Koen Station or Shioya Station. Eventually, we would like to visit famous peaks overseas at our research expense as a future work.

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