IE 324 - Simulation

Fall 2016 Term Project

Wireless mesh networks (WMNs) are communication networks that provide last mile Internet access to users. They consist of radio nodes that are organized in a mesh topology and communicate via wireless media in a multi-hop fashion. In order to lower deployment costs, a few these nodes (that are called gateway nodes) have wired connections to Internet, and the rest of the nodes deliver traffic from the users such as laptops and cell phones in their coverage regions to these gateway nodes. Traffic is propagated along a path by hopping from one node to another until it reaches a gateway which is the destination node. Since the deployment costs are low, WMNs emerged as the preferred Internet access technology especially for developing areas.

An important problem encountered in WMNs is that the signals that are simultaneously transmitted interfere with each other in the wireless communication media (air) to become incomprehensible at the receiver end. In this project, we adopt Time Division Multiple Access (TDMA) scheme that schedules transmissions to occur at different time slots to address the interference issue. In this scheme, a time frame of a very short duration is divided equally into T time slots. These time slots are allocated to links that need to be activated as shown in Figure 1. Nodes continuously store incoming traffic from users in their coverage areas and from other nodes, and forward it over their wireless links to the next node in their path during the allocated time slots. As there is a limit on the amount of traffic that can be transmitted during a time slot, some links may need to be scheduled in several time slots. Then, the same frame structure is repeated periodically.

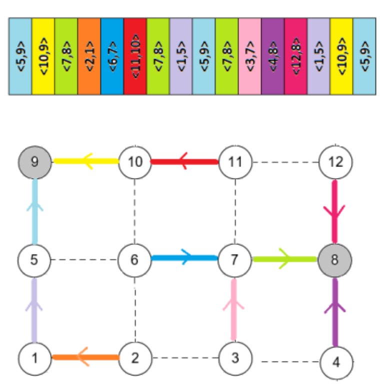

Figure 1. Operation of TDMA Scheme

Common problems studied in WMNs include the gateway node selection, routing and link scheduling. In this project, we consider the network in Figure 2 with $T = 32$ and assume that the gateway nodes, the routing and the number of time slots u_{ij} allocated to each link (i, j) are all given. Our task is to determine the link schedule (the order of these time slots in the time frame) that minimizes the average number of the data packets in the network at the steady state.

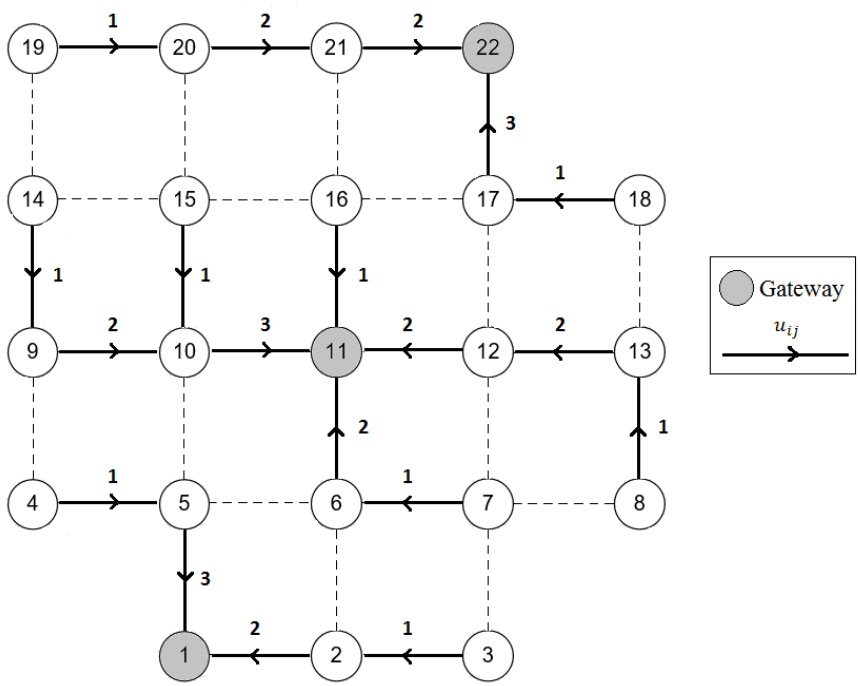

Figure 2. WMN with 22 Nodes

The Little's Law in queueing theory states that the long-term average number of packets in a stable system L is equal to the long-term average effective arrival rate, λ, multiplied by the average time a packet spends in the system, W; or expressed algebraically: $L = \lambda W$. The time spent in WMN is a component in the round-trip delay time, which we would like to decrease to increase the network speed. As the time spent in system is linearly proportional to the average number of packets in system, we consider the minimization of the time-average of the sum of queue lengths over all nodes.

We assume that each node i is receiving traffic according to a Poisson distribution at a rate of d_i packets per second, where

$\mathbf{d}$ = [600, 600, 100, 400, 700, 400, 300, 300, 300, 100, 800, 200, 300, 400, 300, 200, 600, 200, 200, 300, 300, 900]

This traffic can be interpreted as demand, which is collected from the users. Each time frame is 5 ms and it is divided in 32 time slots. In each time slot, we can transmit at most 5 packets on an activated link, in other words, wireless links have the transmission capacity of 32K packets per second. Wired connections at gateway nodes are always activated (TDMA is for wireless links only), and they can transmit 128K packets per second.

As having a wired connection, traffic is directly forwarded to the Internet at gateways. For the remaining nodes, the incoming traffic is stored until it is forwarded over wireless links during the allocated time slots. This storage leads to a queue at each non-gateway node.

The parameter u_{ij} shows how many times the wireless link (i,j) is activated, i.e. the number of time slots allocated to link (i,j). However, it does not give any further information about “when” the link (i,j) becomes active in each time frame. By changing the order of time slots for each link, you are expected to come up with a schedule that minimizes the time-average of the sum of queue lengths over all nodes.

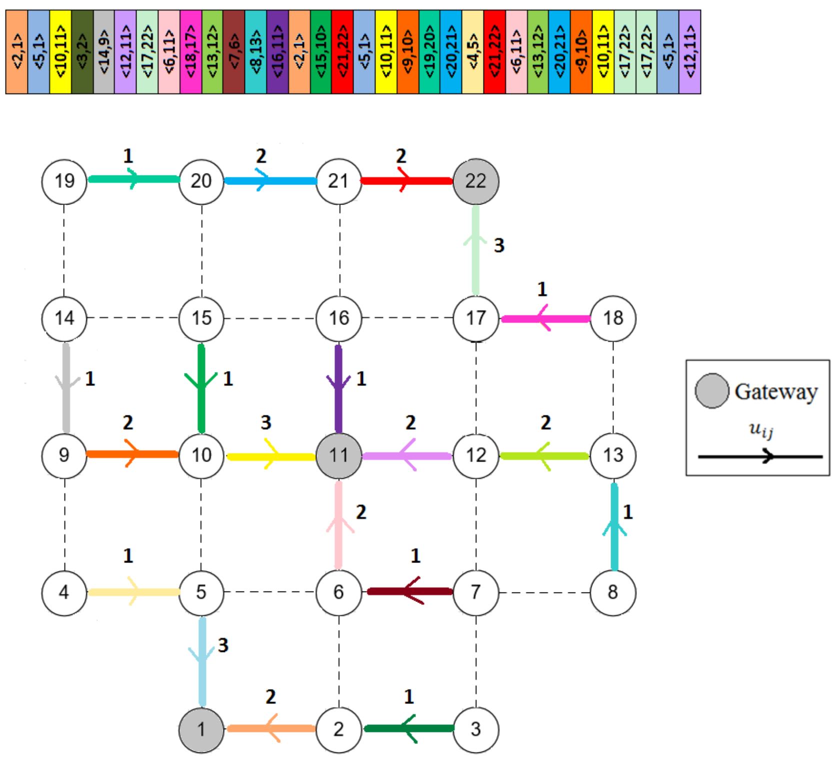

Figure 3. Sample Link Schedule

Figure 3 depicts a sample link schedule. Simulate the operation of this WMN under this sample schedule and determine the time-average number of packets in system and the average time spent in system to verify the Little’s Law. Then, simulate this network with the best link schedule you can come up with. In both simulation models, please plot the individual queue lengths of the nodes and the total queue length over time.