Dynamic Polling MAC
Application Note

www.waverider.com

WaveRider's Dynamic Polling MAC

The introduction of WaveRider's Dynamic Polling MAC establishes new standards in the performance of Fixed Wireless Access (FWA) systems operating in the license-exempt bands. This product upgrade provides significant improvements in the operation and performance of WaveRider's LMS4000 NLOS system resulting in an improved business case for the operator and an enhanced end-user experience.

The Challenges of Outdoor Wireless Networks

WaveRider has always recognized that the operation of outdoor wireless networks presents the service provider with a number of unique performance challenges and problems. A significant number of the wireless outdoor bridges and FWA systems currently in the market and designed to operate in the ISM bands, are based on the IEEE 802.11 standard. The 802.11 standard was designed for compatibility and interoperability for Wireless LAN (WLAN) equipment in an indoor or short distance outdoor environment.

The IEEE 802.11 standard places specifications on the parameters of both the physical (PHY) and medium access control (MAC) layers of the network. The PHY layer, which actually handles the transmission of data between nodes, can use either direct sequence spread spectrum (DSSS), frequency hopping spread spectrum (FHSS), or infrared (IR) pulse position modulation. Key to the performance of a wireless device is the MAC layer. It is the part of the radio device managing the protocol and the usage of the over-the-air link. The MAC layer is responsible for determining a number of functions including authentication, association, re-association, and data transfer. There are a number of different MAC protocols and techniques used by wireless networks. Wireless equipment conforming to the 802.11 standard utilizes CSMA/CA (Carrier Sense Multiple Access/Collision Avoidance).

In low data traffic environments CSMA/CA is an adequate protocol, particularly when there are few radio nodes on the network. In large multipoint networks established for high-speed Internet access services, CSMA/CA places severe limitations on the performance of the network. Radio nodes that need to transmit data on a multipoint wireless network avoid collisions by listening for other transmissions on a channel. If the node hears other transmissions it will wait and attempt to transmit again. When data traffic is high and a large number of nodes are attempting to transmit at the same time, this will lead to every node being in Collision Avoidance mode. In this mode the effective channel capacity of a CSMA/CA-based MAC can fall off to about 20 percent of maximum capacity. As a result, instead of getting 8 Mbps of capacity, the effective channel capacity can fall off to 1.6 Mbps or less.

Theoretically, radio nodes are given an equal chance to access the channel, however CSMA/CA does not share available bandwidth fairly. A node with a strong signal has a greater advantage over a node with a weaker signal, in that the node with the stronger signal being able to capture a greater share of the available bandwidth during transmission.

Another major limitation of CSMA/CA protocol is the "hidden node problem". In order for CSMA/CA to work effectively, all nodes in a wireless network must be able to "hear" each other's packets in order to avoid them. In typical large outdoor wireless networks, most nodes cannot "hear" traffic from other nodes. This inability to hear other remote nodes can be caused by bands of interference between nodes, or physical obstructions such as trees or buildings. When nodes cannot hear each other, several nodes may attempt to transmit their data at the same time. As a result of simultaneous data transmissions, collisions occur and the performance of the network declines significantly as nodes need to re-transmit data.

WaveRider Communications Inc.
255 Consumers Road, Suite 500, Toronto, Ontario, Canada M2J 1R4

Dynamic Polling MAC

To address these performance limitations of the CSMA/CA MAC, several vendors including WaveRider have incorporated a polling MAC protocol into their products. WaveRider's polling MAC implemented in the NCL1170 and LMS2000 system utilizes a "round robin" approach which is similar approach used by other wireless equipment developers. In the "round robin" polling MAC, the base station (CCU) polls all the nodes or EUMs of the network to check if they have data to transmit.

The distance of the node to the base station does not affect its ability to access the base station. Nodes do not have to "hear" each other in order to avoid collisions, as a node can only transmit data when it is polled by the base station. The polling MAC with WaveRider's LMS2000 and NCL1170, enables the operator to build a network with up to 30 nodes or EUMs per CCU or base station. This polling MAC provides WaveRider's 2.4 GHz equipment with industry-leading data throughput specifications.

Although the "round robin" polling MAC does resolve collision avoidance issues and the "hidden node" problem, it is not very efficient in very large networks, in particular those serving residential markets. Since the base station (CCU) has to continuously keep polling each node or EUM irrespective of its probability of transferring a packet, the "round robin" MAC is effective when only a small number of EUMs are transmitting packets. For larger networks, the polling intervals required for nodes waiting to transmit needed to be improved in order not to impact on the end user experience. In order to address the shortcomings of the "round robin" polling MAC, WaveRider developed a proprietary Dynamic Polling MAC.

The Dynamic Polling MAC Advantage

Unique in terms of its features and functionality, WaveRider's Dynamic Polling MAC was developed to enable operators to deploy larger and more complex fixed wireless networks. The Dynamic Polling MAC enables the operator to service more subscribers with a single base station, as a result the business case becomes more attractive as capital costs are reduced. Subscriber revenues are maximized as the Dynamic Polling MAC enables the operator to provide high-speed access services to a larger number of subscribers with different classes of service.

In order to make optimum use of the bandwidth available in the network the Dynamic Polling MAC uses a number of different techniques. The Dynamic Polling MAC is dynamic in that it determines how often an EUM is polled by continuously monitoring traffic flow to/from the EUM. As EUM traffic increases or decreases, polling intervals are modified accordingly. As a result less channel capacity is wasted and the effective throughput increases substantially. This enables a base station (CCU) to support up to 300 EUMs and at the same time provide the end user with better performance.

To accommodate different types of traffic, applications and user requirements, WaveRider's Dynamic Polling MAC incorporates an integrated grade of service (GOS) management algorithm. Within this algorithm, a total of 11 GOS parameters (GOS parameter set) are controlled to achieve specific performance objectives. In the Polling MAC, the GOS determines how often, and when, an *associated* EUM is polled.

It is important to note that the polling algorithm controls packet rates and timing which, in turn, provides varying data throughput in kbps, depending on the packet sizes for a given application. GOS classes are defined based on particular combinations of the GOS parameter set. The system operator assigns a GOS class to each EUM, and the CCU gets the EUM's polling parameters from that class.

WaveRider Communications Inc.
255 Consumers Road, Suite 500, Toronto, Ontario, Canada M2J 1R4

Dynamic Polling MAC

Since it is inefficient to poll an EUM if there is no data to send either way, an EUM can be polled less often if it has not recently transmitted or received traffic. The GOS parameter set essentially provides for independent control of the polling characteristics for both *active* EUMs (those that have recently had traffic) and for *inactive* EUMs (those that have recently had no traffic), where "recently" is defined by the GOS parameter set.

In addition to efficiently managing the usage of the radio link, and providing differentiated service capabilities, the polling MAC inherently "smoothes" the upstream (EUM-to-CCU) packet arrival times. This also has a smoothing effect on the downstream traffic arrivals, which positively impacts network performance by reducing surges in data traffic, transients in queue occupancy, and packet discards.

Configuration files that are stored in the CCU define each GOS. The CCU maintains four assignable GOS configuration files. The operator assigns each EUM to one of these four GOS configuration files, which have the fixed labels of Gold, Silver, Bronze, and Best Effort. Although the labels are fixed, the configuration file that is associated with label determines the actual service level.

Although only four assignable GOS configuration files can exist simultaneously in the CCU, each of these files can be readily changed by FTPing a new configuration file to the CCU, to replace the existing one. This change can be done while the CCU is active, and takes effect immediately.

To illustrate the operation of the GOS configuration files, the performance of the factory default GOS service levels is summarized in the following table. This default GOS configuration file is tailored for networks consisting of both residential and business-class users.

Service Class	FTP Rate	Typical Use
Best Effort	0 – 384 kbps	Standard Residential/SOHO
Bronze	0 – 1024 kbps	Premium Residential/SOHO
Silver	128 – 256 kbps	Small Business
Gold	256 – 512 kbps	Medium Business

The key advantage of the Silver and Gold Service levels is that operator is able to provide a minimum service rate for business customers that require guaranteed performance levels.

Benefits of WaveRider's Advanced Dynamic Polling MAC

The Dynamic Polling MAC enhances the operation of FWA networks using WaveRider's family of wireless equipment products by providing a number of benefits to service operators and their customers.

- **Higher Overall Performance Levels** –eliminates collision errors by EUMs attempting to transmit data to the base station (CCU) at the same time.
- **Optimizes Network Bandwidth** –establishes connections between the base station (CCU) and EUMs based on need to transmit data.
- **Accommodating Sustained Data Traffic** – streaming video, audio, and large data transfers can be accommodated while managing the impact on other users.
- **Better Business Case** – enables more EUMs to be associated with each base station (CCU), maximizing the operator's capital investment and revenue opportunities.
- **Service Differentiation** – allows the operator to offer tiered levels of service, increasing individual subscriber revenue opportunities.

WaveRider Communications Inc.
255 Consumers Road, Suite 500, Toronto, Ontario, Canada M2J 1R4

WaveRider