Tsunami® WORP® Sync Best Practices

Contents

I.   TDMA protocol

Time Division Multiple Access protocol is used as a synchronous protocol based on a fixed time frame structure to enable synchronization between Base Station Units (BSUs).

With TDMA each time frame is itself divided into uplink and downlink slots according to the configured downlink/uplink ratio. These ratios are typically configured with a DL/UL notation, such as 70/30 which means 70% of the time frame and hence capacity is reserved for the downlink communications and 30% is reserved for uplink data.

 In addition, the TDMA frame also has two additional sections, the Intra Frame Delay and the Inter Frame delay.

- Intra Frame Delay refers to the gap inside a single TDMA frame that separates the uplink and downlink portions of the traffic. This "gap" has to account for the distance of the client device that is farthest away to avoid having units switching to transmit mode before the previous packet is fully received.

- Inter Frame Delay indicates the gap or length of time in between individual TDMA frames.

The benefit of TDMA is that if multiple base stations use the same values for Inter and Intra frame delays, as well as the same length time frame and uplink/downlink ratio then it is possible to synchronize these base stations so they are in transmit or receive mode simultaneously and thus greatly mitigate the issue of self interference for a dense deployment of BSUs. The graphic below shows how multiple BSUs with the same timing can operate "in sync."
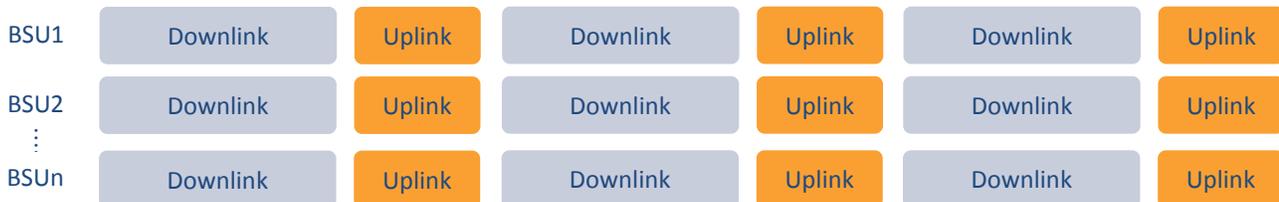
The downside with TDMA is that the capacities for downlink and uplink are static. If the data traffic from a DL/UL perspective does not match the frame UL/DL ratio configuration, it reduces the efficiency of the system.

- If the frame is over-loaded with more data in one direction than it was configured to hold, the result will be packet queuing and data not being delivered on time.

- If the frame is under-loaded, the result will be wasted capacity and lower overall network throughput.

Downlink	Uplink	Downlink	Uplink	Downlink	Uplink

Wasted Time
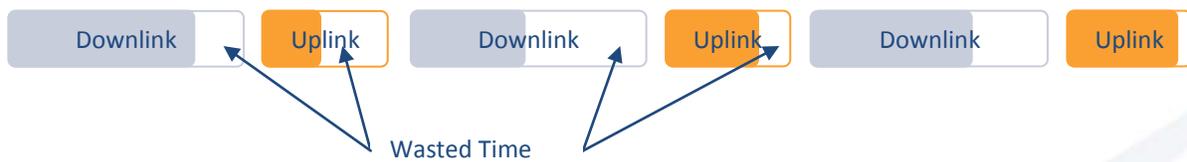
II.   Factors Influencing Performance in a TDMA Synchronous System

As with all wireless media access control (MAC) protocols there are tradeoffs between latency, performance and data capacity/efficiency.

For example, the best way to improve latency is to support smaller or shorter frame sizes. If a system has a 2.5ms frame size, typical round trip latency for a packet of data will be 5 ms or two frames, one for the DL communication and a second for the response in the UL path. However each frame has a fixed overhead, and introducing more frames means more overhead and less actual data throughput – resulting in a less efficient data communications system.

If the desire for the network is to be efficient in traffic-carrying capacity, then large frame sizes are better. With a 10ms frame, the fixed overhead is the same as for a 2.5ms frame, thus more time remains available for throughput. In summary:

- Frame size directly influences both throughput and latency.

- The bigger the frame size, the higher the throughput. Indeed the intra and inter frame delays remain the same and thus represent lower overhead.

- The smaller the frame size, the more transmission slots and thus the shorter the latency. As client devices need to wait for the next transmit slot before being able to transmit the next queued packet, more transmission slots result in shorter waiting time.

Other parameters that impact the performance of a TDMA synchronous protocol in terms of latency and throughput are:

- Range can affect throughput in two ways:
  o The farther the client from its base station, the lower the signal to noise ratio (SNR). Lower SNR results in lower modulation and therefore less throughput.
  o Beyond 2 miles, the intra frame delay needs to be increased to take into account the over-the-air transmission time. This increases the overhead, thus reducing the amount of time available for data transmission.

- The number of clients impacts performance:
  o A Base Station can deliver a fixed amount of data, thus the more clients (also called subscriber units or SUs) that are connected to it the less data is available per client.
  o As each client get access to the media sequentially, the more clients, the longer each client will need to wait before its turn to access the media. Thus the higher the latency.
  As a rough estimate, latency is equal to time-frame in ms * number-of-clients (assuming no sub slots – to be discussed later).
  o Clients with no data to transmit but still connected or registered to the base station need to be queried using a full time frame which carries no data. This also has an effect on the overall throughput of the sector. This is especially important for ISPs with significant over-subscription ratios as the base station will spend most of its time querying non-active clients.

- Quality of Service setting
  o QoS is very important as it helps to properly prioritize the transmission of latency-sensitive packets and ensure that client gets enough air time allocation with the proper delay to manage voice, video or data traffic.

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III.   WORP® Sync

WORP® Sync is a versatile implementation of the TDMA protocol which allows network administrators to fine-tune their transmission patterns to support co-location of multiple Proxim BSUs or even co-existence of Proxim BSUs with other vendor products.

By default, the WORP® Sync time frame is set to 2500 microseconds with minimum intra and inter frame delays of 80 microseconds each. Each time frame is allocated to a single client (zero sub slots or one slot), which provides better throughput efficiency.
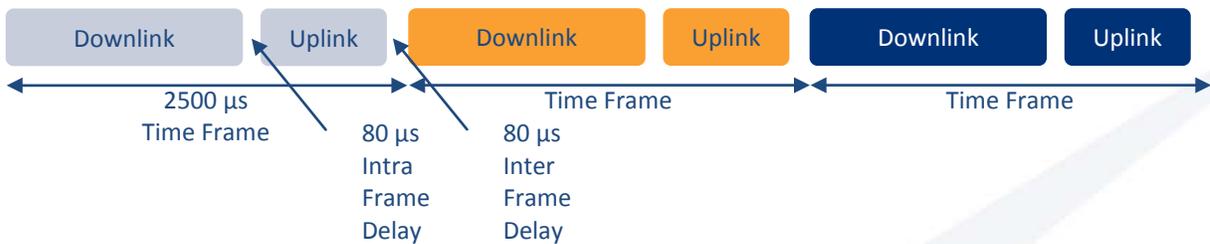
However when passing small packets such as voice traffic, the most important criteria is packet latency. In this case, it is possible to split one time frame into two sub-slots, each allocated to a different client. The result is an improvement in the latency at the cost of 8 to 10 % throughput reduction due to the insertion of the intra slot delay in order to guard times between the sub slots. As an estimate, latency is equal to (time-frame in ms * number-of-clients) / number-of-sub-slots
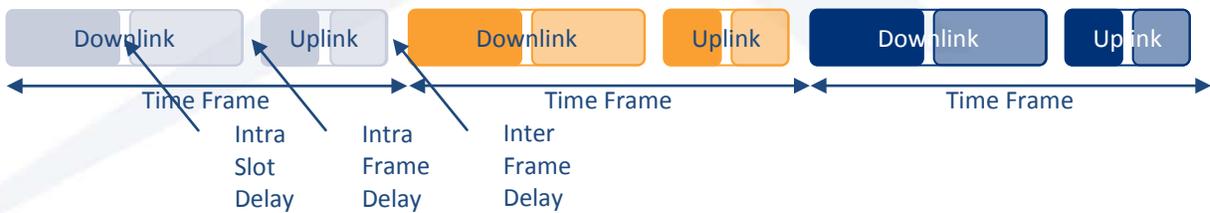
Sub-slot should be long enough to transmit a full packet over the air. So the use of sub-slots is subject to several parameters:

- Channel Size and Modulation which affect the data rate and thus the amount of data that can be transmitted in one sub-slot.

- Time Frame and UL/DL ratio which affect the sub-slot size and thus the amount of time available to transmit data.

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The following table (accessible within the unit WEB GUI) summarizes possible combinations:

Required Minimum Data Rate for Different DL Ratio

Index	DL Ratio	5MHz Single/Auto/Dual Stream	10MHz Single/Auto Stream		10MHz Dual Stream		20MHz Single/Auto Stream		20MHz Dual Stream		40MHz Single/Auto Stream		40MHz Dual Stream	
		Sub Slot 1/2	Sub Slot 1	Sub Slot 2	Sub Slot 1	Sub Slot 2	Sub Slot 1	Sub Slot 2	Sub Slot 1	Sub Slot 2	Sub Slot 1	Sub Slot 2	Sub Slot 1	Sub Slot 2
1	15	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	>=MCS4	N/A	>=MCS10	>=MCS15
2	20	N/A	N/A	N/A	N/A	N/A	>=MCS3	N/A	>=MCS9	>=MCS14	>=MCS1	>=MCS4	>=MCS8	>=MCS11
3	25	N/A	N/A	N/A	N/A	N/A	>=MCS2	>=MCS2	>=MCS9	>=MCS12	>=MCS0	>=MCS2	>=MCS8	>=MCS9
4	30	N/A	N/A	N/A	N/A	N/A	>=MCS1	>=MCS4	>=MCS8	>=MCS11	>=MCS0	>=MCS2	>=MCS8	>=MCS9
5	35	N/A	N/A	N/A	N/A	N/A	>=MCS1	>=MCS2	>=MCS8	>=MCS8	>=MCS0	>=MCS0	>=MCS8	>=MCS9
6	40	N/A	N/A	N/A	N/A	N/A	>=MCS1	>=MCS1	>=MCS8	>=MCS8	>=MCS0	>=MCS0	>=MCS8	>=MCS8
7	45	N/A	N/A	N/A	>=MCS9	N/A	>=MCS0	>=MCS0	>=MCS8	>=MCS8	>=MCS0	>=MCS0	>=MCS8	>=MCS8
8	50	N/A	N/A	N/A	>=MCS8	N/A	>=MCS0	>=MCS0	>=MCS8	>=MCS8	>=MCS0	>=MCS1	>=MCS8	>=MCS8
9	55	N/A	N/A	N/A	>=MCS8	N/A	>=MCS0	>=MCS0	>=MCS8	>=MCS8	>=MCS0	>=MCS0	>=MCS8	>=MCS8
10	60	N/A	N/A	N/A	>=MCS8	N/A	>=MCS0	>=MCS0	>=MCS8	>=MCS8	>=MCS0	>=MCS2	>=MCS8	>=MCS9
11	65	N/A	N/A	N/A	>=MCS8	N/A	>=MCS0	>=MCS0	>=MCS8	>=MCS9	>=MCS0	>=MCS0	>=MCS8	>=MCS8
12	70	N/A	>=MCS2	N/A	>=MCS9	N/A	>=MCS1	>=MCS1	>=MCS8	>=MCS8	>=MCS0	>=MCS0	>=MCS8	>=MCS8
13	75	N/A	N/A	N/A	N/A	N/A	>=MCS1	>=MCS2	>=MCS8	>=MCS9	>=MCS0	>=MCS1	>=MCS8	>=MCS8
14	80	N/A	N/A	N/A	N/A	N/A	>=MCS1	>=MCS4	>=MCS8	>=MCS10	>=MCS0	>=MCS1	>=MCS8	>=MCS8
15	85	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	>=MCS0	N/A	>=MCS8	>=MCS12

Notes:

1. This table is applicable for BSU and SU modes.

Close

WORP® Sync's advanced QoS capabilities help schedule time slot allocation based on client QoS configuration. In order to ensure smooth voice and video propagation across the wireless network, WORP® Sync will also perform temporary static allocation when prioritized traffic is detected. This is especially helpful with variable bit rate streaming flows such as video streams which commonly use a dynamic codec for encoding.

IV.   What performance to expect with WORP® Sync Radios

A.   WORP® Sync – Point-to-Multipoint (PTMP) Throughput Calculator

As noted, there are many factors that can influence the latency and throughput of a synchronous network such as one using WORP® Sync including:

- number of SUs connected
- number of SUs active
- RF interference environment
- modulation per SU
- frame size
- number of sub-slots
- DL/UL ratio

Proxim offers its free calculator tool, the WORP® Sync – PTMP Throughput Calculator (see below exemplary screenshot), to provide guidance as to what to expect when deploying a wireless network using WORP® Sync radios.

Important Note: The provided calculations are not a guarantee of throughput or latency. The data is provided in order to assist with the design of a point-to-multipoint wireless network using Tsunami® 8000/800 product. The calculated latency and throughput are estimated based on default WORP/QoS configuration. Adjusting the settings for the specific network may improve performance, but misconfiguration can badly affect the wireless network's capability.
These calculations assume an unobstructed line-of-sight radio path with adequate clearance for antenna height above terrain and obstructions.
The real-world environment of any installed wireless network could cause actual performance to differ from performance estimated by this calculator.

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Given the number of factors to be considered, this calculator should be used to provide a general estimation of performance in terms of latency and throughput. Actual network results will be dependent on the host of factors listed above. The WORP® Sync Calculator estimates average latency and overall throughput for round robin scheduling (no QoS settings) based on base station settings (time frame, sub-slots, DL/UL ratio, Channel bandwidth) and client characteristics (number, modulation).

Because every real-world deployment is different, Proxim cannot and does not guarantee any specific performance of its products in any particular deployment (beyond the parameters shown in the product data sheets for the specific products).

B.   Live network measurements

The following test results are representative of what performance can be expected in a real life environment and can be used to guide the adaptation of WORP® Sync to match application requirements when operating a network. The following options detail expected network behavior based on type of traffic present. For purposes of this exemplary presentation, measurements were performed with 25 clients per sector. For the reasons described above, increasing the number of clients would both increase latency and decrease overall sector performance.

- For a data heavy network, the goal is to achieve the highest throughput performance. This often can be achieved with the default configuration: 50/50 % UL/DL ratio, 2.5 ms time frame with one sub-slot and default QoS. All latency numbers are round trip.
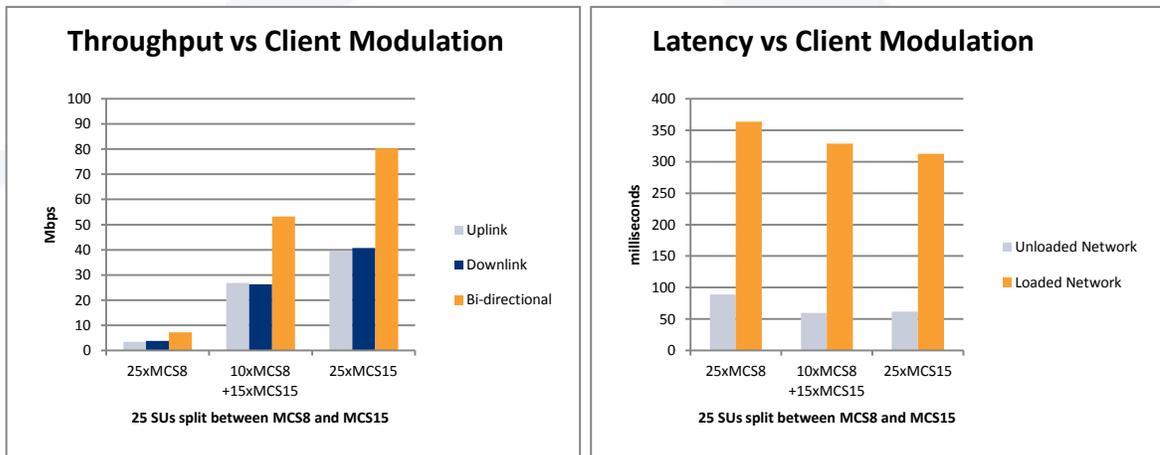
- For a video oriented network, the goal is to ensure low latency for that video traffic while transmitting a huge amount of information. This can been achieved by optimizing QoS and giving the highest priority to the video flow.
  The benefit is a greatly reduced latency for time-sensitive applications even with a loaded network while the effect on throughput is negligible. As described above, increasing the number of clients would both increase latency and decrease overall sector performance.
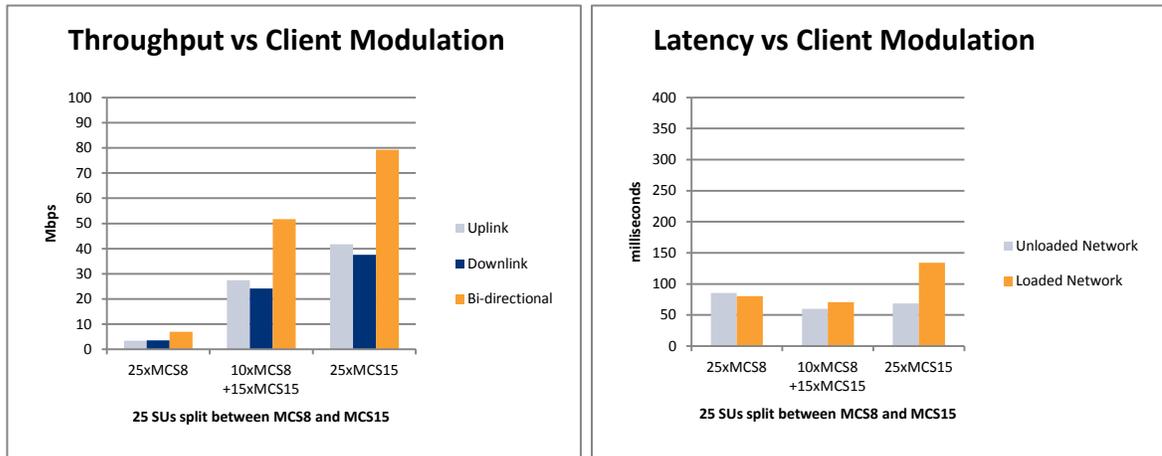
- For networks supporting a preponderance of Voice over Internet Protocol (VoIP) traffic, the goal is to provide very low latency for optimum voice quality. This can be achieved by optimized QoS and giving highest priority to the voice traffic together with the use of 2 sub-slots per time frame.
  The benefit is to reduce latency by half for time-sensitive applications even with a loaded network. However, the effect on throughput is a reduction by an average of 8% of sector overall performance. As described above, increasing the number of clients would both increase latency and decrease overall sector performance.

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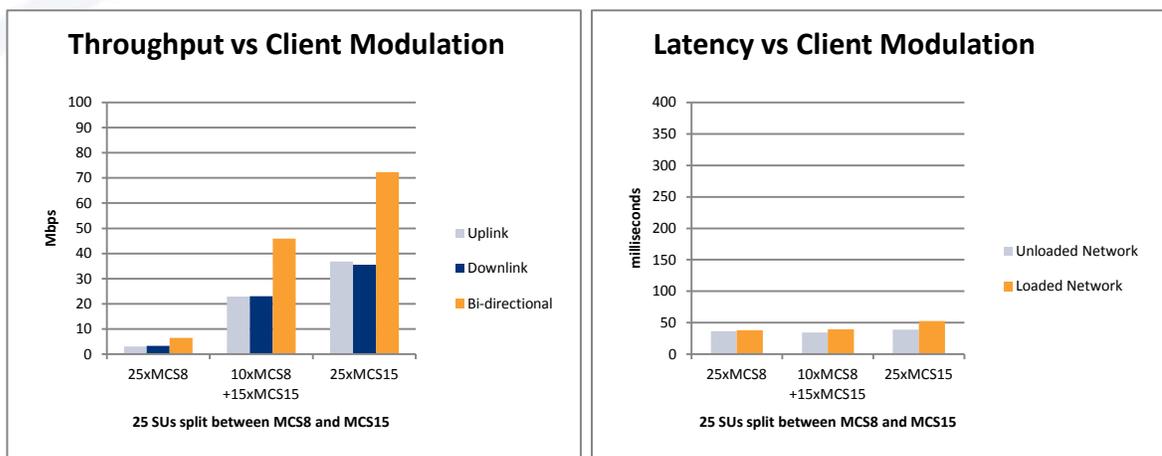
V.   Conclusion

When deploying a wireless network employing a TDMA synchronous protocol such as WORP® Sync, there are inherent tradeoffs between latency and throughput. It is important to understand the applications being run on the network in order to configure it for best performance. The network test results shared above and the WORP® Sync Calculator provide guidance as to how to configure your network for your applications and an idea of what to expect in terms of latency and throughput. However given the complexities of real-world networks and the limited high level variables which are addressed in the calculator, these calculator results are only be used as guidelines.

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Appendix A – WORP® Sync Throughput Calculator Configuration Fields

This Appendix provides detailed instructions on what and how to fill in the field for the WORP® Sync – PTMP Throughput Calculator.
Fields are in order from the top left of the tool to the lower right.

A.   Input Parameters

Parameter	Description	Configuration
Time Frame in ms	If the unit is operating in conjunction with alternate vendor systems, this time frame must match the co-located equipment operating time frame. If the unit is operating in a Greenfield mode, selection of frame size should be based on the traffic to be transported.	The smaller the frame size, the better the latency performance. The larger the frame size, the better the throughput performance. If mixed mode traffic is to be supported, e.g. voice and data, 2.5ms and 5ms are likely the best choices.
Number of Sub-slots	Sub-slots are used to improve latency performance, but have an impact on throughput as there are guard intervals between each sub-slot consuming capacity.	Note that for the 2.5ms frame size, channel sizes under 20MHz are not permitted in conjunction with 2 sub-slots. For larger frame sizes all channel sizes support a configuration of 2 for the number of sub-slots.
Minimum Modulation	The system supports modulations per SU. These can range from a low of BPSK to a high of 64QAM. Single refers to single stream of PHY data. Dual stream refers to dual PHY layers or MIMO.	Determine which SU on the network has the lowest modulation and enter that rate into this field. Note that the calculator only supports 8 level of modulation.

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Parameter	Description	Configuration
Maximum Modulation	The system supports modulations per SU. These can range from a low of BPSK to a high of 64QAM. Single refers to single stream of PHY data. Dual stream refers to dual PHY layers or MIMO.	Determine which SU on the network has the highest modulation and enter that rate into this field. Note that the calculator only supports 8 level of modulation.
DL and UL ratio	These two parameters describes in percentages how much of the overall system capacity is reserved for Downlink or Uplink data. It is important to configure this as close to what your network will see as possible as misconfiguration can result in wasted capacity.	When choosing the DL percentage, the calculator will automatically fill in the UL percentage. Note that some configurations of very unbalanced links (85/15) are not supported in the smaller frame sizes. Please refer to the table displayed Page 6 of this document.
Maximum Distance	This represents the distance of the SU farthest away in the BSU sector. The number is used to determine the Inter Frame parameter by the system.	Select if the distance is expressed in miles or km.
Channel Bandwidth	The channel size being used by the SU.	Configuration can range from 5MHz to 40MHz, although it needs to be noted per above that 2.5ms Frame size only supports 20 and 40MHz channel sizes.
Guard Interval	The Guard interval represents the "buffer" between two OFDM signals and has an impact on multipath performance and throughput.	Two choices – 400ns or 800ns with 800ns offering the better robustness to multipath effect and 400ns offering the better throughput. Note that 400ns is only available for 40 MHz channels.
WORP Sync Profile Details	These fields can be configured either manually or with auto fill.	

Parameter	Description	Configuration
Auto fill	Fill in the box indicating the total number of SUs in the network. The calculator will then automatically fill in a uniform distribution of modulations for the total number of SUs	Total number of SUs. Once entered click "Auto fill."
Oversubscription Rate	This number represents the oversubscription ratio of the network. If the ISP or carrier has a sector that supports an aggregate capacity of 100Mbps of actual throughput, it is common to sell and support 2, 3, 5 or even 10 times the available throughput due to the statistical multiplexing nature of bursty data. The oversubscription rate is set by the ISP or carrier as they decide.	Choices for the oversubscription ratio range from none – indicating no oversell, to 20 to 1.

When finished click "Auto Fill" |
| Manual Configuration | Determine how many streams and what modulations and data rate at which each SU in the network is operating. All SUs registered to the BSU must be accounted for whether they are currently transmitting data or not. | Enter into the number of SU field the total number of SUs at each data rate. |
| Active SUs | Represents the average number of SUs that will be active at any given time per data rate. When this field is used to, the calculator automatically configures the oversubscription rate when calculating performance. | If there are 10 SUs at a given modulation, and the number of active SUs at any given time is 2, the system will calculate an oversubscription ratio of 5 (10/2). |

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B.   Output Parameters

The outputs of the WORP Sync calculator are not guarantees of link performance. The data is provided in order to assist with the design of a wireless link using Tsunami® 8000/800 product. The calculation is a general estimate based on altitude extrapolation without visiting the potential link location and does not take into account any man-made obstacles. This calculated estimate does not replace a real site survey performed by an experienced specialist, which Proxim recommends always be performed before installing any wireless link. The real-world environment of any installed wireless link could cause actual performance to differ from performance estimated by the calculator.

Output Field	Description
Average Expected Round Trip Latency per SU	This represents the average expected latency per SU. Among the factors not considered for this output calculation that can cause deltas between the calculator and actual performance are mixes of traffic types and congestion in the RF domain. Note that this is the round trip latency. For application support, typically one way latency is the targeted performance specification, in which case this number needs to be divided by 2.
Practical TCP Throughput	The average expected total throughput for all DL and UL connections as well as the total of the two are represented in these fields.