ENTITLEMENT MONITORING

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INTRODUCTION

128 Technology provides flexibility to enterprises with two software licensing models: capacity-based and project-wide. Similar to traditional router licenses, the capacity-based license entitles an organization to a maximum bandwidth on a specific 128T Router. The project-wide license is a new approach which entitles an enterprise to a bandwidth utilization applicable to a pool of routers. This white paper provides a comparison of how the entitlements associates with the two licenses are measured and monitored by the 128T Networking Platform.

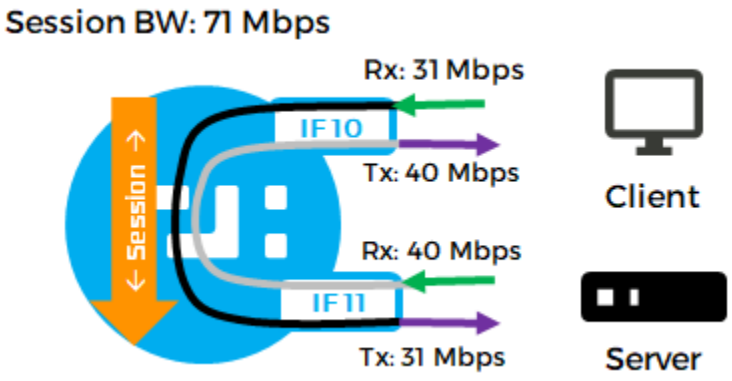
CAPCITY-BASED MONITORING

A capacity-based license applies to a single 128T Router in an authority. The 128T Networking Platform provides several methods for the administrator to monitor performance relative to the entitlement, as illustrated in multiple scenarios in the following sections.

SINGLE-SESSION MONITORING

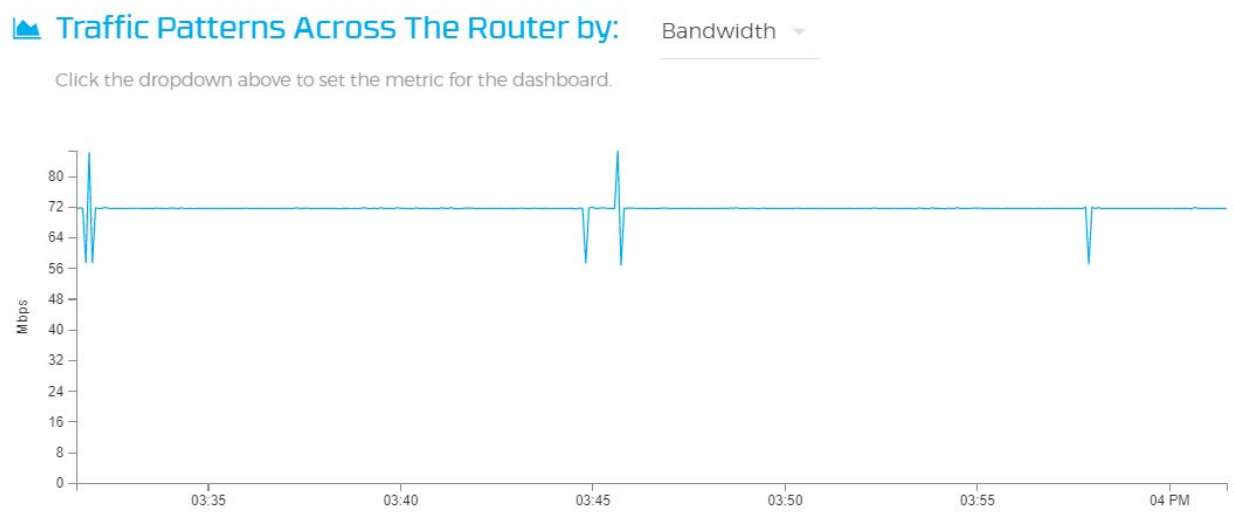
The 128T Router is session-oriented, so the router monitors entitlements from a session perspective. An example of a 128T Router with a single session illustrates the basic concepts and terminology.

Consider the 128T Router shown below, where a client is accessing an application at a server via the 128T Router. Sessions are how users interact with applications in unique, bi-directional, two-way exchanges of information. In the figure below a session is made up of two flows; one flow initiates from the client to the server, and the server responds with a second flow to the client. The 128T Router characterizes the bandwidth of a session by summing the bandwidth of the flows in each direction. In this example, the flow from the client to the server has a bandwidth of 31 Mbps, which is received (Rx) from the client by interface IF 10 and is transmitted (Tx) to the server on interface IF 11. The responding flow has a bandwidth of 40 Mbps, which is received (Rx) from the server by interface IF 11 and is transmitted (Tx) to the client on interface IF 10. The session bandwidth is the sum of the two flows, 71 Mbps.



The 128T Networking Platform includes a user interface with multiple methods to monitor the system. Similar to traditional routers, the platform displays the *Device Interface Average Bandwidth*. From the 128T Router or Conductor Graphical User Interface (GUI) the average bandwidth over a user-specified time period (e.g. 30 minutes) on each device interface is visible when selecting a particular node. All packet types on the interface are counted. For the scenario above the average interface bandwidth on both interface IF 10 and IF 11 is ~71 Mbps, as shown below.

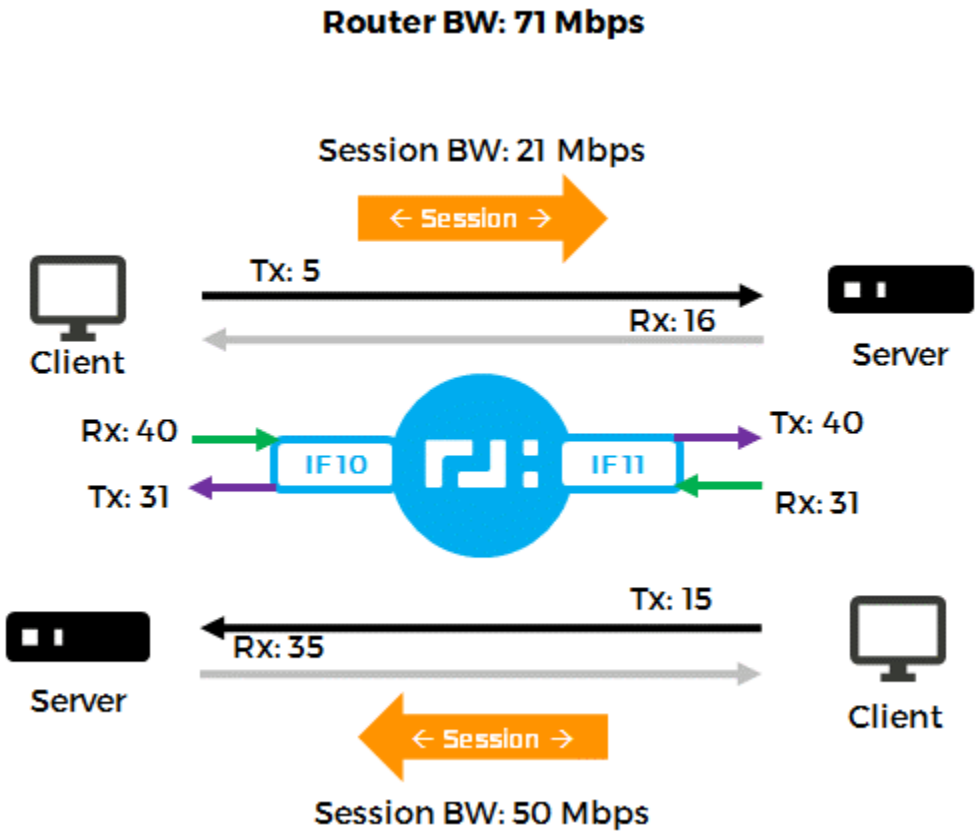
The *Router Bandwidth* is calculated based on the sessions present in the router. This bandwidth measurement is available through the Router or Conductor GUI on the dashboard page for the specified Router. The most recent bandwidth is measured on a 5 second interval and is plotted as a function of time. Sessions associated with a designated management interface are not included, but all other sessions are tabulated. In the scenario above the bandwidth as a function of time is ~71 Mbps, with slight variations in time, as shown below.



To monitor the operation of a router relative to a capacity-based entitlement, the system calculates the *Peak Router Bandwidth Capacity*. This is simply the highest *Router Bandwidth* value of any 5 second interval over the specific license period of 1 or 3 years. Determining compliance with the license simply requires comparing the *Peak Router Bandwidth Capacity* to the *Licensed Peak Router Bandwidth Capacity*, which is specified in the capacity-based license. Continuing the example above, with a 1 year capacity-based license, compliance is determined by measuring *Router Bandwidth* over the 12 month period. In the figure below the *Peak Router Bandwidth Capacity* is ~88 Mbps around month 6, and the *Licensed Peak Router Bandwidth Capacity* is shown at 70 Mbps. In this scenario the license has been exceeded, so the enterprise should increase their *Licensed Peak Router Bandwidth Capacity* at the next license renewal. Significantly, compared to most competitors 128 Technology does not enforce the *Licensed Peak Router Bandwidth Capacity* with traffic policing. A 128T Router will not drop all packets above the specified rate for license enforcement, and the *Peak Router Bandwidth Capacity* can exceed the license without penalty as illustrated below.

MULTI-SESSION MONITORING

Compared to the simplistic example above, in practice routers typically have many session traversing the data plane simultaneously. In the diagram below a case of two sessions in opposite directions are traversing a router. In this case for the top session the left-to-right flow is 5 Mbps, and the right-to-left flow is 16 Mbps, creating a session bandwidth of 21 Mbps. The bottom session has flow in the right-to-left direction of 15 Mbps and in the left-to-right direction of 35 Mbps, for a session bandwidth of 50 Mbps.

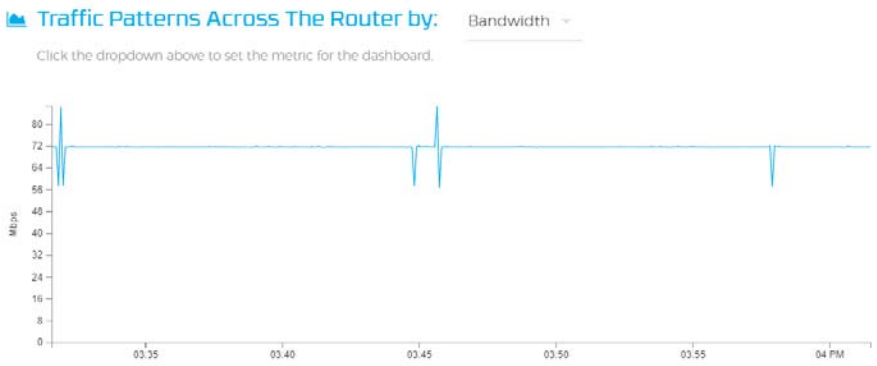


In this case the interface bandwidth is calculated based on the sum of the various components. Interface IF 10 is receiving (Rx) 40 Mbps (5 (top) + 35 (bottom)) and transmitting (Tx) 31 Mbps (16 (top) + 15 (bottom)). Interface IF 11 is simply the opposite of IF 10, transmitting (Tx) 40 Mbps and receiving (Rx) 31 Mbps. With a constant bit rate on the interface during the averaging period, the GUI would display a *Device Interface Average Bandwidth* of ~71 Mbps.

List of Device Interfaces

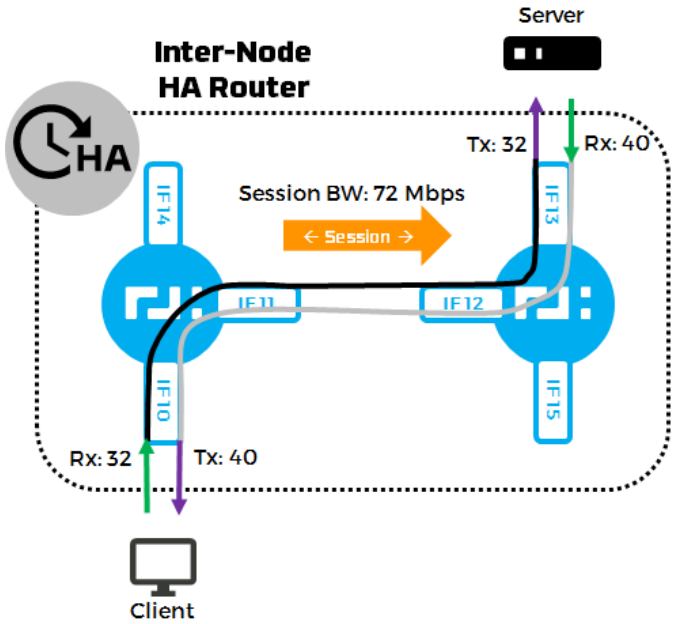
Device Interface	Network Interface	Type	Total Data (GB)	Avg. B/W (Mbps)
nyc:10	1	ethernet	16.06	71.38
nyc:11	1	ethernet	16.06	71.39

The 128T *Router Bandwidth* is based on the sum of the magnitude of all sessions traversing the data plane of the router. In this example the *Router Bandwidth* is the sum of the two sessions, 71 Mbps (21 (top) + 50 (bottom)). Over time the GUI dashboard represents the bandwidth traffic pattern across the router.



HIGH-AVAILABILITY SESSION MONITORING

A 128T Router with multiple nodes configured in High-Availability (HA) monitors bandwidth to take into account redundancy. In the example below, two nodes are configured for redundancy, with an inter-node connection on interfaces IF 11 and IF 12. In certain states sessions may traverse both nodes, as shown with a session initiating from a client on interface IF 10 and destined for a server on interface IF 13. In the *Router Bandwidth* calculation, sessions are only counted once, even if they appear on multiple nodes of the same router. In this case the 72 Mbps session traverses both the left and right nodes, but the *Router Bandwidth* of the HA router consisting of two nodes is 72 Mbps.

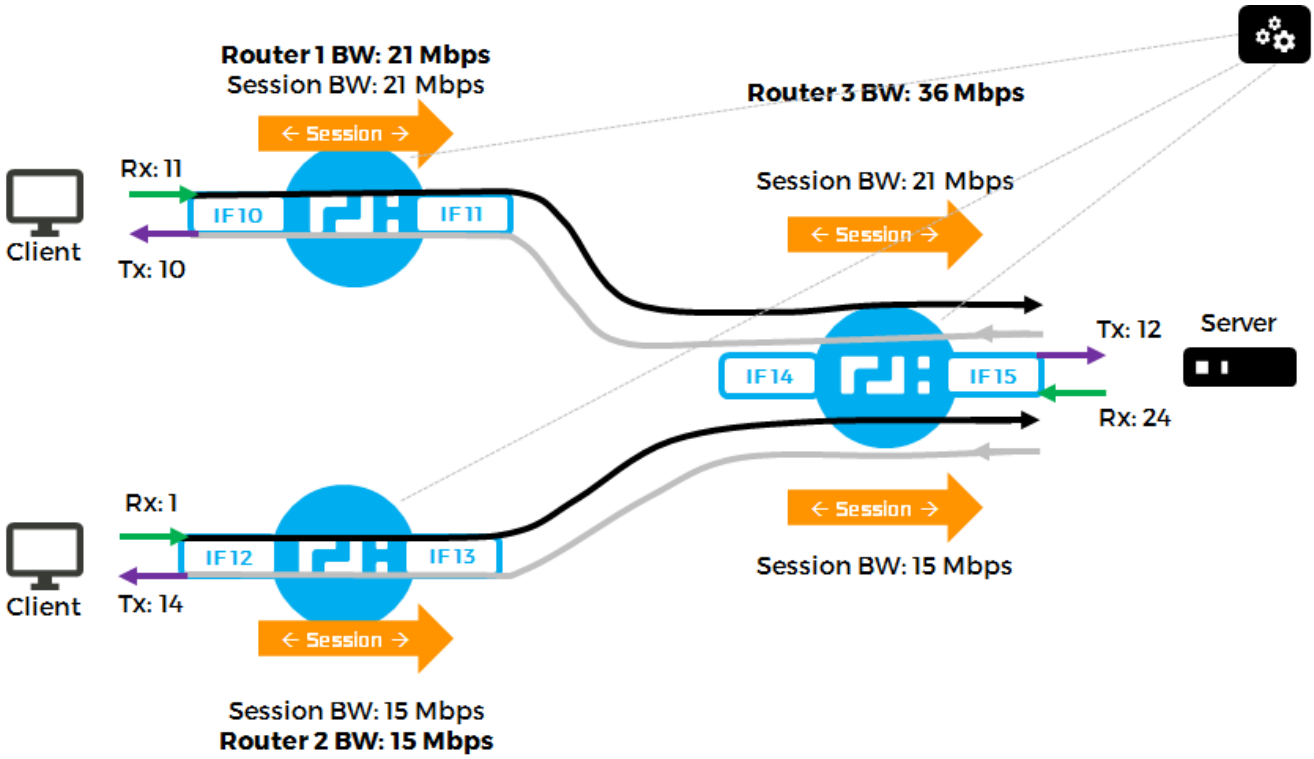


PROJECT-WIDE MONITORING

128 Technology also provides a project-wide license which applies to a group of routers in an authority. The 128T Conductor provides multiple project-wide monitoring tools. This section provides representative examples of the key utilization metrics with uniform bandwidth and time-varying bandwidth assumptions.

UNIFORM BANDWIDTH EXAMPLE

The figure below illustrates a scenario for monitoring of a project-wide license for a simplistic case. This uniform bandwidth case assumes the sessions present remain at a constant bandwidth for the entire month. In this scenario three routers are connected together. Sessions initiate from clients at Routers 1 and 2 to a server located at Router 3. The client at Router 1 initiates an 11 Mbps flow toward the server at Router 3, and the server responds with a 10 Mbps flow, producing a session of 21 Mbps present at both Router 1 and Router 3. The client at Router 2 initiates a 1 Mbps flow toward the server at Router 3, and the server responds with a 14 Mbps flow, producing a session of 15 Mbps present at both Router 2 and Router 3. The *Router Bandwidths* are 21 Mbps at Router 1, 15 Mbps at Router 2, and 36 Mbps at Router 3 (the sum of the two sessions).



As shown above, the 128T Conductor collects bandwidth information from all the routers in a project and performs several calculations. The *Project-Wide Time-Averaged Bandwidth* is calculated for each 5 minute

interval in a month by summing the average bandwidth in a 5 minute interval of all the routers in the project. In this case:

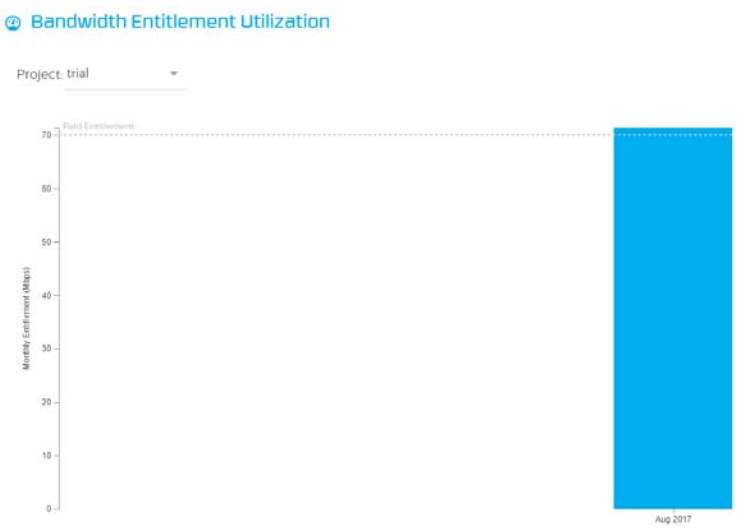
$$Project\text{-}Wide\ Time\text{-}Averaged\ BW = Router\ 1\ Time\text{-}Averaged\ BW + Router\ 2\ Time\text{-}Averaged\ BW + Router\ 3\ Time\text{-}Averaged\ BW$$

$$Project\text{-}Wide\ Time\text{-}Averaged\ Bandwidth = 21\ Mbps + 15\ Mbps + 36\ Mbps$$

$$Project\text{-}Wide\ Time\text{-}Averaged\ Bandwidth = 72\ Mbps$$

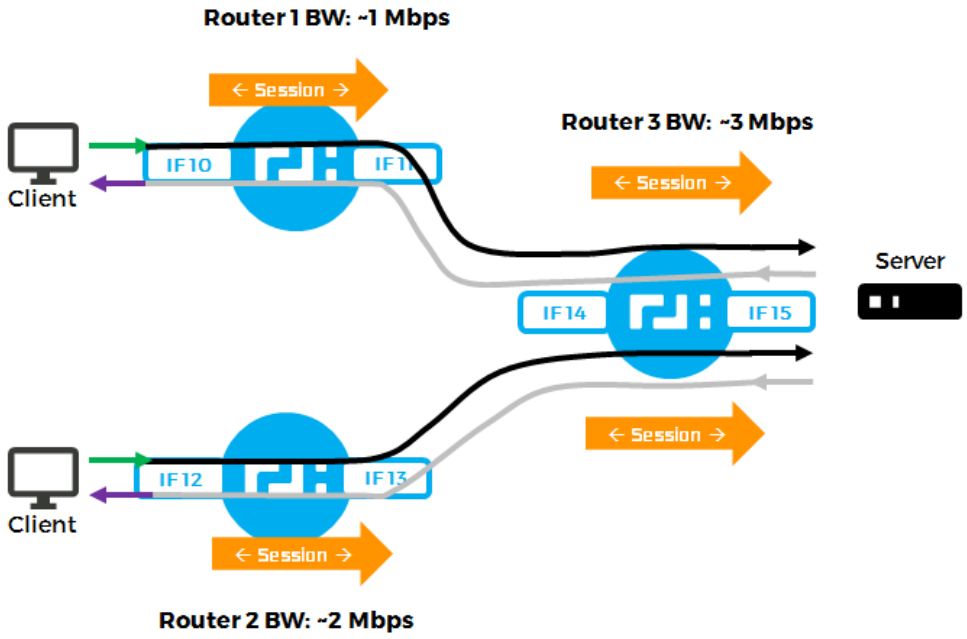
Since the bandwidth of all sessions are uniform in time, for every 5 minute interval in a month the *Project-Wide Time-Averaged Bandwidth* is 72 Mbps.

The 128 Technology project-wide license specifies a *Licensed Peak Project-Wide Bandwidth Utilization* and the number of *Licensed Project-Wide Sites* over a 1 or 3 year period. For each calendar month, the system calculates a *Monthly Project-Wide Bandwidth Utilization*, and then over the license period tracks the *Peak Project-Wide Bandwidth Utilization* as the highest month in the license period. The *Monthly Project-Wide Bandwidth Utilization* is calculated as the 95th percentile of the ordered list of 5 minute *Project-Wide Time-Averaged Bandwidth* measurements in the calendar month. In the example above, because of the uniform time distribution, the *Project-Wide Time-Averaged Bandwidth* is 72 Mbps for every 5-minute period in the month. Accordingly the 95th percentile is also 72 Mbps. Therefore the *Monthly Project-Wide Bandwidth Utilization* is 72 Mbps. Each monthly value is displayed in the Conductor GUI on the Bandwidth Entitlement Utilization chart:

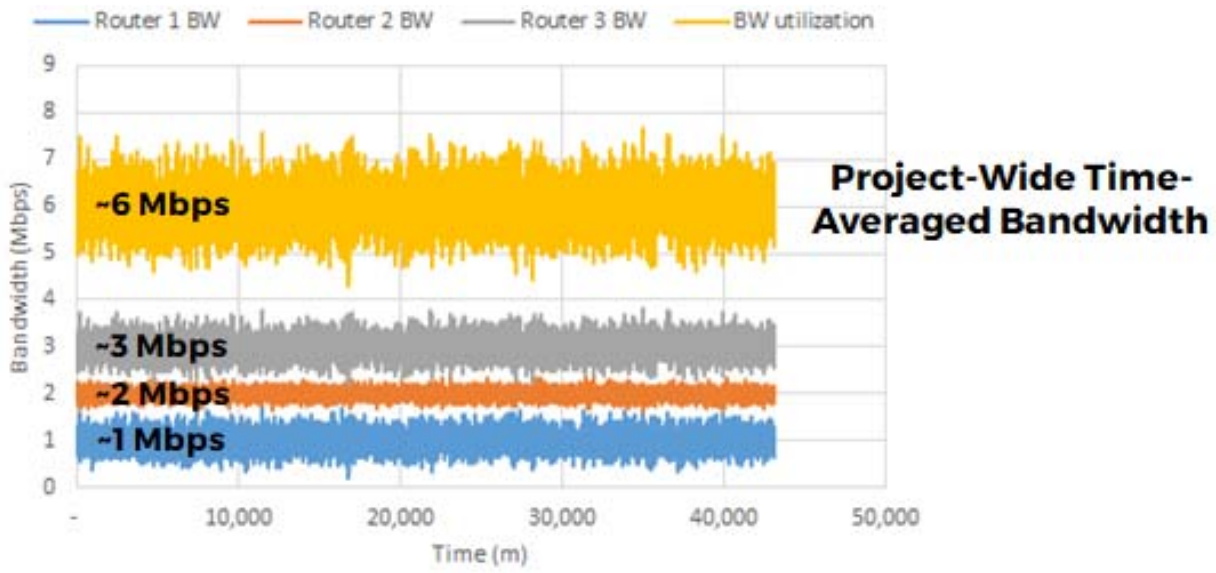


TIME-VARYING BANDWIDTH EXAMPLE

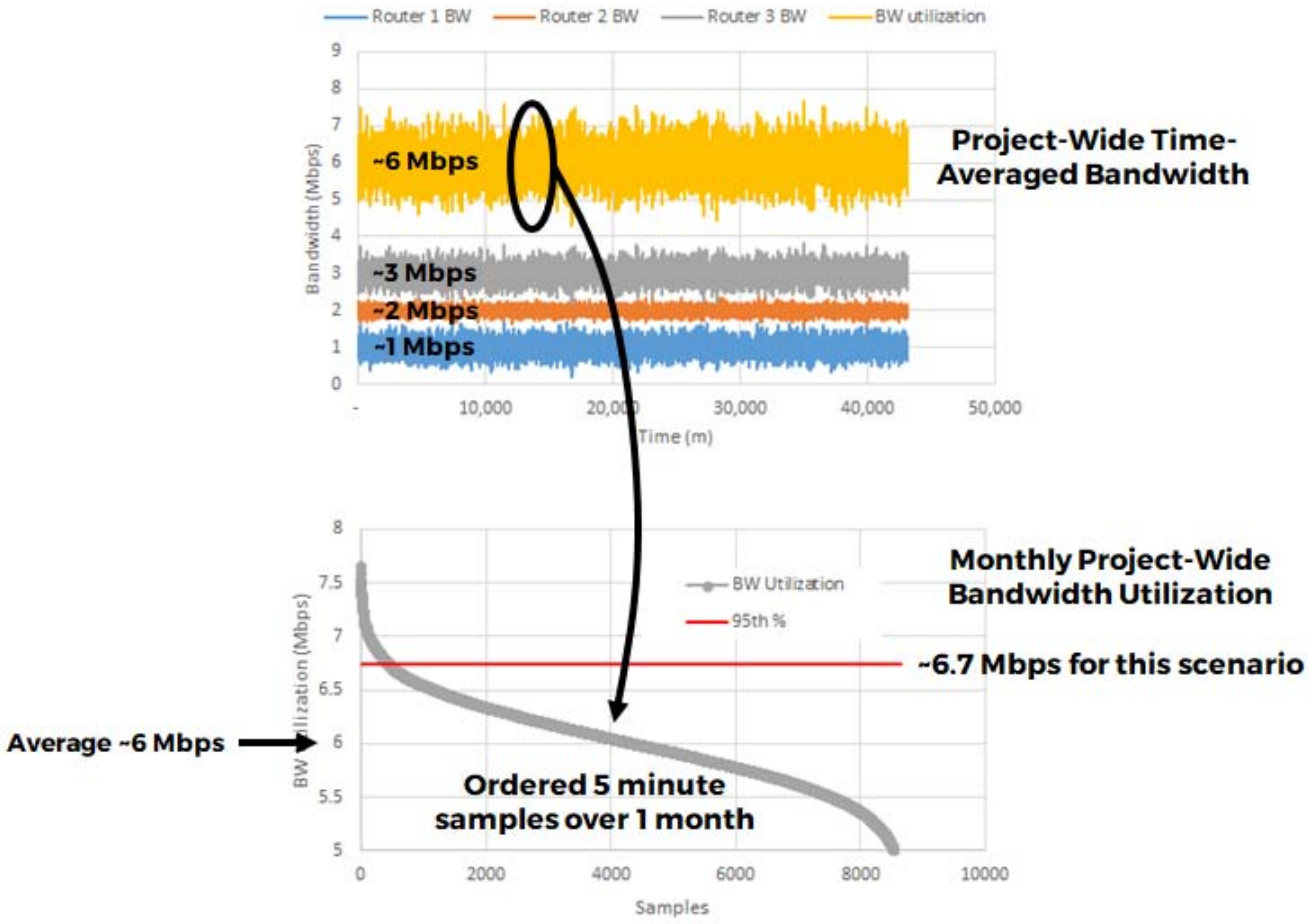
In most real-world scenarios the bandwidth and number of sessions will vary in time. The example below duplicates the network topology of the previous section, but the session bandwidths and characteristics have been changed. As before sessions are initiated from clients at Routers 1 and 2 to a server at Router 3. Instead of a constant bandwidth in time, this scenario assumes the bandwidth for each session has a normal distribution with the average bandwidth specified. Since the bandwidths vary from each 5-minute to 5-minute sample, only the approximate (~) bandwidths are represented in the figure.



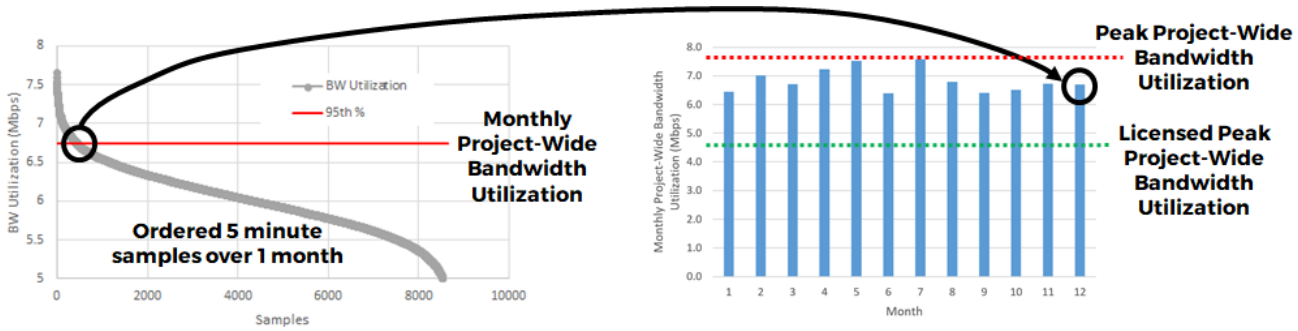
Bandwidth versus time graphs help to visualize the time variations, as shown in the figure below. All bandwidth samples in the figure are on a 5 minute interval, and all the samples for one month are plotted. In the graph the blue curve is the Router 1 bandwidth which has a normal distribution with an average bandwidth of 1 Mbps and a standard deviation of 0.2 Mbps. The orange curve is the Router 2 bandwidth which has a normal distribution with an average bandwidth of 2 Mbps and a standard deviation of 0.1 Mbps. The grey curve is the Router 3 bandwidth, which is the sum of Router 1 and 2, based on the connectivity of the topology, and has an average bandwidth of 3 Mbps. Finally the yellow curve is the *Project-Wide Time-Averaged Bandwidth* which is calculated as the sum of all three routers at each 5-minute point in time.



The 128 Technology project-wide entitlement is based on the 95th percentile. As shown below, to calculate this quantity for a specific calendar month all the 5-minute samples of the *Project-Wide Time-Averaged Bandwidth* are ordered from largest to smallest. Then the largest 5% of samples are disregarded and the 95th percentile value is selected as the *Monthly Project-Wide Bandwidth Utilization*. In this numerical example the average value across the month is 6.0 Mbps, the peak is 7.7 Mbps, and the 95th percentile value is 6.7 Mbps.



To compare with the project-wide license, each *Monthly Project-Wide Bandwidth Utilization* is tabulated for the entire license period. The figure below illustrates how the last *Monthly Project-Wide Bandwidth Utilization* value is calculated and displayed on a bar chart for the 12th month of the period. *The Peak Project-Wide Bandwidth Utilization* is simply the largest *Monthly Project-Wide Bandwidth Utilization* across the license period and highlighted with a red dashed line. For reference the *Licensed Peak Project-Wide Bandwidth Utilization*, which is specified in the project-wide license, is also shown as a green dashed line. In this specific example, the *Monthly Project-Wide Bandwidth Utilization* for the 12th month is 6.7 Mbps. The *Peak Project-Wide Bandwidth Utilization* is 7.6 Mbps, and the *Licensed Peak Project-Wide Bandwidth Utilization* is 4.7 Mbps. In this particular example, the organization is exceeding the licensed value, so for the next renewal, 128 Technology would recommend modifying the project-wide license for a higher *Licensed Peak Project-Wide Bandwidth Utilization*.



CAPACITY VERSUS PROJECT-WIDE

As explained in the previous sections, the capacity-based and project-wide approaches are quite different, and target different enterprise needs.

The 128 Technology capacity-based license is quite similar to traditional router licenses, specified with a maximum bandwidth capacity, node-locked to a particular instance, and familiar to acquisition and operations organizations. As previously discussed, the 128 Technology approach is advantageous because the 128T Router does not drop packets based on the licensed capacity. For many organizations, the familiarity of a capacity-based license simplifies procurement.

The project-wide license offers is an innovative new approach with a number of compelling benefits. Since project-wide bandwidth utilization incorporates both averaging and the 95th percentile, enterprises pay for utilization, not low-probability, short, bandwidth bursts. This approach is elastic instead of node-locked, so licensed capacity is never stranded on a little-used router. Finally the advantages of elasticity and utilization can create considerable cost savings for enterprises.

SUMMARY

Recognizing the diverse needs of enterprises, 128 Technology provides two different software licensing options. The capacity-based license is similar to traditional router licenses and is monitored based on *Peak Router Bandwidth Capacity* on a per-router basis. The project-wide license is a new approach based on *Peak Project-Wide Bandwidth Utilization* across a group of routers. This Entitlement Monitoring Whitepaper details the methods the product uses to monitor these two license types, providing insight into which approach may be most applicable to particular enterprises.

GLOSSARY

Device Interface Average Bandwidth – This is the average bandwidth on a specific device or network interface of a single router. It is a single number, which is the average over the selected display period (e.g. 30 minutes, 1 day, etc.). This is an informational quantity, especially useful for troubleshooting.

Router Bandwidth – This is the average bandwidth across a single router over a 5 second interval based on the sessions traversing a router. It is independent of router interfaces. Typically multiple of these samples are viewed on a time-based graph. This is an informational quantity, useful for operations.

Peak Router Bandwidth Capacity – This is the peak value of the *Router Bandwidth* samples for a single router during a 1 or 3 year license period. This is a single number that indicates whether a specific router is operating in compliance with a capacity-based license.

Licensed Peak Router Bandwidth Capacity – This is the bandwidth specified in the capacity-based license for a single router during a 1 or 3 year license period. This is a single number to which the *Peak Router Bandwidth Capacity* is compared.

Project-Wide Time-Averaged Bandwidth – This is the sum of average bandwidths, on 5 minute intervals, across all routers in project, based on the sessions traversing each router. Typically multiple of these samples are viewed on a time-based graph. This is an informational quantity, useful for understanding project-wide variations on intervals shorter than a month.

Monthly Project-Wide Bandwidth Utilization – This is the 95th percentile of the *Project Wide Time-Averaged Bandwidth* for one calendar month. This is a single number and an information quantity, which is useful for understanding how project-wide utilization varies by month.

Peak Project-Wide Bandwidth Utilization – This is the peak value of the *Monthly Project-Wide Bandwidth Utilization* values in the 1 or 3 year license period. This is a single number that indicates whether the project is operating in compliance with a project-wide license.

Licensed Peak Project-Wide Bandwidth Utilization – This is the bandwidth specified in the project-wide license for a group of routers during a 1 or 3 year license period. This is a single number to which the *Peak Project-Wide Bandwidth Utilization* is compared.

Monthly Project-Wide Sites – This is the maximum number of sites measured across a project during a calendar month. The number of sites is based on unique locations, if assigned, or the number of unique routers, if no locations are assigned in the configuration.

Peak Project-Wide Sites – This is the peak value of the *Monthly Project-Wide Sites* values in the 1 or 3 year license period. This is a single number that indicates whether the project is operating in compliance with a project-wide license.

Licensed Project-Wide Sites – This is the number of sites specified in the project-wide license for a 1 or 3 year license period.

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