Engineering overview for TEACH and Authorized Users

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BadgerNet Core Network

The next generation of BadgerNet is a unique combination of commercially available, ubiquitously provisioned Layer 2 service in the Access Layer of the network and a remarkably inexpensive, highly available Aggregation/Core Layer. This combination provides the greatest use of commercially available services while minimizing the expense of state-specific resources.
Categories of Service

BadgerNet offers 4 categories of service:

1. **Category A**: WAN with QoS
2. **Category B**: WAN without QoS (best effort and discard-eligible)
3. **Category C**:
   i. Broadband Internet Symmetrical
   ii. Broadband Internet Asymmetrical
   iii. MIS over BadgerNet
4. **Category D**: Private Metro Ethernet with QoS (available in regions 3, 4, 5, 8, or 9 only)

**Category A and Category B** services are provisioned with a Service Provider Network Termination End-Point (SP NTE), as well as a BadgerNet Juniper Switch NTE. Whenever practicable, both Category A and B service will be served with a fiber-based circuit. Services may be provisioned as copper for lower bandwidths.

**Category C** services are considered “Best Effort” services (lowest class of service), which means traffic is discard eligible when the network congests.

(i) **Symmetrical** and (ii) **Asymmetrical** traffic follow the same pattern: traffic is handed off to an ISP as soon as possible, and the local Service Provider is also the ISP. And, in both (i) and (ii), the AT&T Network Monitoring Interface (NMI) does not have visibility to the Category C end-points. Users requesting this service are required to call when service is down.

Symmetrical (i) Category C service will most often be connected to the provider ISP through their Metro Ethernet cloud, and will provision with a Service Provider NTE (not BadgerNet).

Asymmetrical (ii) Category C service will follow the route that all DSL or Cable modem subscribers use and use a DSL or Cable modem.

(iii) **Managed Internet Service (MIS) over BadgerNet** is a hybrid service that combines Category B (or Category A) transport with an AT&T MIS portal. The transport delivers the traffic from the remote site to either the Madison or Milwaukee Core. The traffic is handed off at the core to the AT&T MIS Portal. This service is only available utilizing BadgerNet Category B (or Category A) transport and only with the AT&T MIS Portal.

An option to use another provider is currently not offered to Category C subscribers.

**Category D** service is a true Metro Ethernet Service, only available in regions 3, 4, 5, 8, or 9. Category D service does NOT have a connection to the BadgerNet core, but is meant to be used as a Private Network. If connectivity to BadgerNet is also needed, a separate Category A or Category B circuit must be ordered and the End User is responsible for routing traffic between their Category D private network and their Category A or B connection to BadgerNet and vice versa.

Bandwidth requirements for this category insure a fiber connection and a Service Provider NTE terminates the circuit. There is no BadgerNet Juniper Switch NTE on Category D service.
A Category D connection may be added to Category A and Category B services by splitting the requested connection. Split increments are:

1) Available in increments of 1 Mbps.
2) Dedicated to the specific category.
3) Policed at the requested bandwidth.

For example, on a 1 Gbps Category A service, the end user may request AT&T split the connection with 500 Mbps to Category A and 500 Mbps to Category D. Traffic from the Categories of Service will be delivered on separate VLAN’s or ports on the BadgerNet Juniper Switch NTE to the customer. The customer may route traffic between the two networks, AT&T will not provide this routing functionality. Traffic from a remote Category D service will flow to the combined connection in to the customer router where it may be routed back out to a Category A remote site, effectively hair-pinning the traffic.

A visual diagram of how Category A – D services are provided is included below:

**QoS Information**

Quality of Service (QoS) parameters associated with Category A and Category D will be honored and preserved through the network. The QoS markings are introduced in the End User’s network, honored and preserved at the BadgerNet PE/Core and pass back to the Access Layer for service delivery.

Preservation of QoS markings is dependent on the egress service category only. If Category A traffic is destined for a Category B site, the QoS on the traffic from the Category A site will be honored throughout the network but will be treated as best effort on egress to the site. Traffic from the
Category B site (to the Category A) will have QoS best effort markings that will be preserved and honored throughout the network.

For Category A and Category D, the following QoS queues will be available:

2. Interactive (Video): High Priority – Latency Sensitive, can handle 1% packet loss
3. Critical Applications: Reserved for AT&T NMI
4. Business Critical Applications
5. Best Effort
6. Non-Critical (Internet) Discard-eligible traffic

The End User equipment is responsible for marking their traffic with the appropriate DSCP markings for Category A. For Category D service the End User equipment must mark the correct 802.1p markings. The BadgerNet core equipment will honor the markings for Category A and Category D services.

**Differentiated Services Code Point (DSCP) Table**

<table>
<thead>
<tr>
<th>Priority</th>
<th>Traffic types</th>
<th>Managed Service</th>
<th>QoS</th>
<th>DSCP Values</th>
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<tbody>
<tr>
<td>0 (lowest)</td>
<td>Non-Critical (Internet)</td>
<td>CoS 5/scavenger</td>
<td>AF11/12, CS1</td>
<td>8-15</td>
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<td>1</td>
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<td>EF, CS5</td>
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</table>

The Per-Packet Class of Service (PPCoS) Serving Arrangement allows the network to provide individual prioritization levels on a frame by frame basis predicated on Ethernet priority bit settings (802.1p). With the PPCoS Serving Arrangement, a CoS ‘profile’ determines the allocations for each of the supported priority bit markings. PPCoS allows the service PE to provide differentiated service on a frame by frame basis from the Provider Edge (PE) to the End User access equipment.

For each Category A and D service connection, the customer may select a CoS profile. The profile specifies the amount of bandwidth reserved for each CoS class in case of congestion. **Customers should first decide how much Real-time/Voice (CoS1) and Interactive/Video (CoS2V) bandwidth is needed**, then select a profile with CoS 2>= CoS3 >= CoS4 >=CoS5. If a profile is not selected, the highlighted profile included in the table below will be used. Category B sites cannot select a profile. Some of the recommended Category A and D CoS profiles are included below:
## Per-Packet Class of Service (PPCoS) Profile Table

### Category A and D Profiles

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### Category B Profiles

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</table>

March 15, 2017
The service recognizes 6 unique priority markings as follows:

**CoS 1 (Real-Time): 802.1p – 5**
Supports applications that require minimal loss, are latency-sensitive and require low latency variation (jitter), including voice and video. The service parameters associated with Real-Time CoS are Packet Delivery Rate (PDR), Latency, Jitter, and Network Availability.

**CoS 2v (Interactive): 802.1p – 4**
Supports high-priority business data applications or jitter-sensitive applications such as voice and video. The service parameters associated with Interactive CoS are PDR, Latency, Jitter, and Network Availability.

**CoS2 (Business Critical-High): 802.1p – 3**
Supports most business data applications with moderate tolerance for delay and which are more sensitive to jitter, and have a higher priority than Business Critical - Medium.

**CoS 3 (Business Critical-Medium): 802.1p – 2**
Supports most business data applications with moderate tolerance for delay and which are less sensitive to jitter. The service parameters associated with Business Critical-Medium CoS are PDR, Latency, and Network Availability.

**CoS4 (Non-Critical High): 802.1p – 0**
Supports low priority business applications with more tolerance for delay and availability. The service parameters associated with Non-Critical High CoS are PDR, Latency, and Network Availability.

**CoS 5 (Non-Critical Low): 802.1p – 1**
Supports the lowest priority traffic for applications with tolerance for delay, loss, and jitter, or applications where performance can be degraded during times of network congestion.

**WAN Transformation**

**IP Addressing:**
IP addresses assigned from the legacy BCN network will transfer to the new BadgerNet network. End Users will not be required to re-address equipment to connect to the BadgerNet network.
Circuit and NTE Equipment Installation:

The Service Provider’s Network Termination Equipment (SP NTE) will be placed in the telco demarcation room and connected to the Service Provider’s network using fiber for bandwidths of 10 MB and greater. Copper can be used for lower bandwidths.

A BadgerNet Juniper Switch NTE will be located in the minimum point of entry (MPOE) next to the Local Telco NTE. AT&T will provide optical patch cords required for connecting the SP NTE to the BadgerNet Juniper Switch NTE. The BadgerNet Juniper Switch NTE (or SP NTE in the case of Cat D) will be connected to the End User’s network using the requested standard connection type. The connection may be 100BASE-T, 1000BASE-T, 1000BASE-SX (multi-mode fiber), 1000BASE-LX (single-mode fiber), 10GBASE-SR (multi-mode fiber) or 10GBASE-LR (single-mode fiber). Interface type will be determined/defined on the equipment site survey. The End User will be required to provide anything necessary to connect from the BadgerNet Juniper Switch NTE (or SP NTE in the case of Cat D) to the End User device.

For purposes of standardization, interfaces will be set to 'auto negotiate'. The customer may request that 100 Mbps and 1000 Mbps (1 Gbps) sites to be hard coded to their respective speeds on the End User facing NTE.

Queuing and frame drops are unavoidable in most complex network designs. The key to effectively managing these is to develop and deploy an effective enterprise performance management strategy. **It is recommended that the End User shape traffic flows per VLAN or per Interface as not to exceed network circuit bandwidth.**

WAN Site Transformation from legacy BCN to the new BadgerNet

WAN Site Transformations will be scheduled per the Transformation Phasing Process.

For organizations with a hub-and-spoke design (one head-end connected to multiple other sites):

1. AT&T will prioritize installing the head-end circuits first, followed by the remote sites. It may not always be possible due to scheduling or installation timeframes in every case. If a remote site is installed prior to the head-end transformation, AT&T will ensure the remote site has connectivity to the non-transformed sites as well as any previously transformed sites.

2. When maintaining existing BCN IP addresses, remote sites cannot be connected to the legacy BCN and BadgerNet at the same time. As the site is cutover to the new network, the legacy BCN circuit will follow the process documented in the transformation plan for decommission.
3. Data traffic from transformed sites to non-transformed sites on the legacy BCN network will be permitted by AT&T establishing a route between the old and new sites for layer 3 sites or by creating a layer 2 Ethernet virtual channel (EVC) between the networks for layer 2 sites. End Users can also keep a connection into the legacy BCN and add a circuit into the new BadgerNet at the End User’s head-end location to route between the networks. This option would require paying for both head-end circuits until the legacy BCN service is removed.

4. IP tunneling should not be affected. End Users can establish IP tunnels between all their sites while in this hybrid state.

Resiliency on BadgerNet

BadgerNet has been designed with resiliency in the core network. If any single circuit in the core fails, traffic will automatically route over the redundant pathway from the affected P or PE router through the network. All Access Layer circuits are connected to a single PE router today on the legacy BCN. The current point-to-point configurations will be moved from legacy BCN to the equivalent BadgerNet PE router unless otherwise specified in the circuit order. Each remote site will only connect to one of the provider PE routers, not both.

Resiliency Options for Category A, B, and D Services

A request for resiliency requires custom quoting, and you must ask your DET contact to request a proposal. These descriptions are using AT&T standard options, which will be translated into the different providers’ offerings where available.

Upon request, circuits may be ordered with Diverse Access, Alternate Access Failover, Alternate Serving Switch or Router other than Normal. Each of these options for resiliency is described in more detail below:

1) **Diverse Access** provides transmission paths, which are diverse from each other, between two designated ASE Service Port Connections at the same End User premises and an ASE Service switch. This solution requires 2 services, which may be in the same or different Category’s, for example a Category A on a separate path from Category D.
End User Interest in Special Construction to Enable More Diversity

AT&T and some End Users may recommend a maximum level of diversity between Diverse Access ports. However in many cases, existing network facilities may not support complete diversity and additional Special Construction (SC) costs may be chargeable to the end user. In the event that facility conditions do not allow maximum diversity as described below, the pre-sale design engineer will specify the extent of common path and (via the Sales Representative) the End User would have the option of accepting the design or may decline to purchase the Diverse Access feature.

- **Provider NTE:** The Diverse Access ports will be terminated on separate NTE (required). The two NTE’s shall be powered from two different End User power sources (recommended) or both NTE may be powered with dual power supplies served by circuits on separate breakers. The End User may also deploy an Uninterruptible Power Supply (UPS) to sustain the NTE in the event of a commercial power failure. Upon request, AT&T companies may provide a quote for the sale and installation of the End User owned UPS, although this is not an optional feature associated with AT&T Switched Ethernet Service. Please contact your AT&T Account Manager for details.

- **Entrance Facilities:** If the End User has existing (or is willing to construct) dual entrance facilities suitable for AT&T services (subject to Special Construction charges from AT&T), AT&T will provision the Diverse Access ports via separate entrance facilities (recommended). If there is only a single entrance facility, AT&T will provision using a fiber pair that is either in a separate conduit or cable where available. If the End User does not have dual entrance facilities and has not requested the construction of such with the Diverse Access ports, End User is deemed to have accepted the common path between the NTE and the first available manhole beyond the End User’s property line. No notification or exception procedure will be required since it will be clear the 2nd entrance does not exist.

- **Loop Fiber Facilities:** AT&T engineers will attempt to deploy the Diverse Access ports over fiber loop facilities that are physically separate by at least 10 feet. Normally this would preclude...
using the same street path and serving wire center (Central Office) (recommended). In the event there is no existing path to a different serving wire center, the AT&T engineer will select a path to the same serving wire center that is physically separated from the reference port to the extent allowed by facilities (i.e. separate conduit, cable, etc.) but which may have some common path including the entrance or termination in the Central Office.

- **Switch and Inter-Office Facilities:** Once the fiber facility for each Diverse Access Port is connected to its respective Serving Wire Center via the loop fiber facility, the path to the serving switch of the two Diverse Access ports shall be diverse to the extent facilities exist or can reasonably be constructed. If two core switches are within reach, the Diverse Access ports would be served by two different switches. If only one switch is available, the two ports would be terminated on different ports and cards (slots) within the same switch.

The Diverse Access feature incurs a Monthly Recurring Charge associated with each of the two ports involved in the diverse arrangement. Non-recurring charges and/or Special Construction charges may be applicable.

2) **Advanced Access Failover (AAF)** provides automatic failover to a redundant facility in the event of a failure of a protected facility. This is a single protected circuit from any available Category.

AAF is available only for 1Gbps or 10Gbps End User Port Connections and is ordered on a per port basis.

**End User Interest in Special Construction to Enable More Diversity**

AT&T and the State of Wisconsin would prefer a maximum level of diversity in the AAF facilities. However in many cases, existing facilities may not support complete diversity and to construct them may incur Special Construction (SC) costs chargeable to the End User. In the event that facility conditions do not allow maximum diversity as described below, AT&T will specify the extent of common path and the BadgerNet subscriber would have the option of accepting the design or may decline to purchase the AAF feature.

A port that has the AAF feature (AAF-port) will include the following levels of protection:
• **Provider NTE:** The functionality inherent in AAF requires a single NTE and single End User interface. The NTE will detect a failure in one path including the network facing interface (east or west) on the NTE and if the working path fails it will switch to the alternate path.

• **Entrance Facilities:** If the End User has existing (or is willing to construct) dual entrance facilities suitable for AT&T services (subject to Special Construction charges from AT&T), AT&T will provision the AAF port using one entrance for each fiber facility (recommended). If there is only a single entrance facility, AT&T will provision using fiber pairs that are in separate conduit or cable where available. If the End User does not have dual entrance facilities and has not requested the construction of such with the AAF port, End User is deemed to have accepted the common path between the NTE and the first available manhole beyond the End User’s property line. No notification or exception procedure will be required since it will be clear the 2nd entrance does not exist.

• **Loop Fiber Facilities:** AT&T engineers will design paths for the two fiber pairs between the NTE and the target core switches such that they are physically separate by at least 10 feet. Normally this would preclude using the same street path and serving wire center (Central Office) for both facilities (recommended). In the event there is no alternate path to a different serving wire center available, the AT&T engineer will select two paths to the same serving wire center that are physically separated to the extent allowed by facilities (i.e. separate conduit, cable, etc.) but which may have some common path including the entrance or termination in the Central Office. In such cases, AT&T will notify the End User Contact identified on the service request that the facility would have the specified amount of common path and End User would have the option of accepting the design or may decline to pursue the AAF port order.

• **Inter-Office Facilities:** Once each AAF access facility is connected to its respective Serving Wire Center the path to each serving switch shall be diverse to the extent facilities exist or can reasonably be constructed. In the event there is only one IOF path available, AT&T will notify the End User of the extent of the common path and the End User may accept the design or decline to order AAF.

• **Core Switch:** Because the two access facilities are terminated on two different switches, if the working switch fails the failover is enacted and the facility which uses the other switch is activated.

While AAF does not specifically refer to failures within the AT&T Switched Ethernet Service core network (i.e. beyond the first terminating switch), the core network MPLS architecture includes diverse paths to multiple switches to minimize the impact of a single path failure within the core.

Advanced Access Failover feature incurs a Monthly Recurring Charge associated with the applicable port. Non-recurring charges and/or Special Construction charges may be applicable.

3) **Alternate Serving Switch** provides Service from a core provider switch that is different from the
switch that would normally serve the End User’s premises. There are no specific limits as to when this feature may be ordered. An End User may be ordering two AT&T Switched Ethernet Service ports at the same (or different) location and may order this feature to ensure that they are served from two different core switches, based on the assumption that it is unlikely (though not impossible) for both switches to become unavailable at the same time. An End User that has other AT&T services served from a given Central Office may be using the AT&T Switched Ethernet Service port as part of business continuity plan and want to avoid that primary Central Office. The Alternate Serving Switch feature does not include diversity of fiber path, nor is there an implied relationship to another AT&T Switched Ethernet Service port. Since both Diverse Access and Advanced Access Failover include using an alternate switch if available, the Alternate Serving Switch is NOT applicable when those features are applicable—i.e. they are mutually exclusive. When the End User subscribes to Alternate Serving Switch, the AT&T port inventory system will indicate the port was provisioned using Alternate Serving Switch for future maintenance purposes. The Alternate Serving Switch feature incurs a Monthly Recurring Charge on the applicable port. Non-recurring charges and/or Special Construction charges may be applicable.

4) **Route Other Than Normal** is an End User request for a configuration that would NOT be covered under one of the above features and yet is within AT&T’s reasonable control to consider.

**ISP Migration to Category C (iii) MIS over BadgerNet**

**MIS over BadgerNet** is an overlay service that requires a Category A or Category B connection to BadgerNet.

When the BadgerNet Internet option is selected by an organization, AT&T will collect from the requesting organization:

1. The percentage of Category B or Category A service to be used for Internet.
2. The number of IPv4 Addresses being requested or the IP Address range(s) already assigned. There is no pre-determined limit on the number of IP addresses supported, so long as the request complies with AT&T’s IP Address assignment policy.

AT&T will configure a layer 2 EVC or VLAN from the End-Users BadgerNet circuit to one of the

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BadgerNet ISP Routers located in Madison or Milwaukee. If the Category B or A circuit is to be split between Internet access and BadgerNet access, the MIS over BadgerNet service will be provided on a second port on the BadgerNet Juniper Switch NTE. A second port on the customer’s edge (CE) device will also be required. Layer 3 Internet connectivity will be established between the customer’s edge (CE) device and the selected ISP edge router. Either customer’s IT staff or contractor must then configure the new interfaces facing BadgerNet with the new IP addresses. Traffic shaping should be configured on the customer’s edge (CE) device that connects to the BadgerNet Juniper Switch NTE.

Managed HD Video Transformation

AT&T will be connecting the legacy BCN and the new BadgerNet to support existing HD Video services as required in the contract. When a site is transformed to the new BadgerNet, the traffic will travel over the BadgerNet core to the legacy BCN to access video sites on the legacy BCN for Managed Video.

We anticipate migrating the codecs from the legacy BCN to the new BadgerNet Network prior to start of school in the fall. Sites that are not yet transformed will continue to access video resources by traversing the legacy BCN to BadgerNet. Existing HD codec IP addresses will remain unchanged. Support for Managed HD video will end October, 2018. Following transformation, new sites will be provisioned on the new BadgerNet video services (Bluejeans).

Migration from BCN to BadgerNet

Migration from legacy BCN to BadgerNet will first consist of two site surveys: circuit and equipment. The local telco will perform a walkthrough to identify requirements for their circuit. The circuit visit will confirm the demarcation of the local telco data circuit that will support BadgerNet. While AT&T is the overall project coordinator – local circuit installation may be provided by either – AT&T, Frontier, CenturyLink, or Access Wisconsin. The equipment survey will be performed by AT&T for the BadgerNet Juniper Switch NTE (Network Termination Equipment) installation. The equipment survey will determine the environment for the Juniper switch and the LAN interface.

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The Juniper switch is a BadgerNet network monitoring device installed only at Category A and B locations. These switches are used for the BadgerNet network management team to monitor performance and provide service reporting. These switches will support separating services, such as Internet, voice, or video, onto separate ports.

Locations will be responsible for providing:

1. A rack or backboard on the wall at the telco Minimum Point of Entry (MPoE) for mounting the telco NTE.
2. Power and grounding for telco and BadgerNet equipment, 15A NEMA5-15 outlet for each.
3. Category D locations - Wiring or patch panel between the telco patch panel to End User equipment.
4. Category A and B locations – Wiring or patch panel between the BadgerNet Juniper Switch NTE and the End User equipment.

To facilitate a smooth transition, wherever possible, the existing BCN connection will remain in use until the new circuit is established and confirmed. If a hot cut is required, the End User will be notified during the ordering process. Once testing is complete, migrating the site traffic to the new circuit is established and confirmed. Once the migration is completed, final testing will confirm application usability. After the site is operating on BadgerNet, the old BCN circuit can be disconnected.

**BlueJeans**

BlueJeans is a managed video service and interoperable cloud-based video communications service that connects participants across a wide range of devices and conferencing platforms. Connectivity to BlueJeans Service may be either through the Internet or directly off BadgerNet core routers.