APPENDIX A

Auction 904 Short-Form Application Operational Questions

Operational History

1. Has the applicant previously deployed consumer broadband networks (Yes/No)? If so:

a. Provide the date range when broadband service was offered and in which state(s) service was offered. Specify dates for each state.

b. Provide an estimate of how many subscribers are currently served in each state. (If the applicant is no longer providing service in any state, estimate the number of customers that were served at the beginning of the last full year that the applicant did provide service.)

c. What services (e.g., voice, video, broadband Internet access) were or are provided in each state?

d. List any data-usage limit (data cap) used as part of existing broadband access services.

e. What specific technologies and network architecture are used for last-mile; middle mile/backhaul; and internet interconnections?

f. What are the deployed voice technologies and how are these voice services implemented?

Proposed Network(s) Using Funding from Auction 904

Answer for each state the applicant selected in its application:

2. Network Infrastructures:

a. Briefly describe from a high-level network perspective which network architectures and technologies will be used in the applicant's proposed deployment. If there are variations by state, region, or other criteria, describe each network or location.

b. Last-mile: What are the relevant topologies, technologies and protocols and the corresponding industry standards for the last-mile network infrastructure in the applicant's proposed deployment?

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c. Middle-Mile/Backhaul: What are the relevant topologies, technologies and protocols and the corresponding industry standards for the middle-mile/backhaul network infrastructure in the applicant's proposal?

d. Internet Access: What are the relevant topologies, technologies and protocols and the corresponding industry standards for the Internet access network infrastructure in the applicant's proposal? This is the connection to major IXPs, transit providers, etc.

e. If the applicant is proposing to use non-standard technologies and protocols, the applicant should identify which vendor(s) and product(s) are being considered and provide links to the vendors' websites and to publicly available technical specifications of the product(s).

3. Voice Services:

1 If technical specifications for the non-standard technologies are not available on a vendor's website, technical documents may be submitted with the application.

a. Briefly describe the anticipated system(s) that will be used to provide voice services to the applicant's subscribers, including a standalone voice service. Examples of such solutions could include: (1) internally designed and operated; (2) provided by a Managed Voice Service Provider; or (3) or an OTT (Over-The-Top) solution available to subscribers via the applicant. If the applicant is considering multiple solutions, provide information on each one and identify possible vendors or service providers.

b. If the applicant plans to use an internally designed and operated system, provide specific information on any existing voice system the applicant operates.

c. If the applicant plans to implement a new system to meet these requirements, provide specific information on the technology, standards, latency, planned QoS, architecture; design; protocols; equipment; vendors; public switched telephone network (PSTN) interconnections (links, speed and to whom you interconnect); capacity (projected peak call rates versus total projected subscribers); reliability and availability design and procedures; and the applicant's specific plans to control, manage, monitor, and recover/repair/troubleshoot outages. If any of these issues are addressed in response to the other questions in this Appendix, it is permissible to cross-reference that information here.

4. Network Performance:

a. Can the applicant demonstrate that the technology and the engineering design will fully support the proposed performance tier, latency, and voice service requirements for the requisite number of locations during peak periods (Yes/No)?

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Answer:

Yes, our fiber access architecture, capable of providing both data and voice services can be easily demonstrated.

Note: Short Form applicants must make a commitment to demonstrate their solution upon request by the FCC.

b. Briefly describe the capabilities of the network technologies that will enable performance tier (speed and usage allowance), latency and (where applicable) voice service mean opinion score (MOS) requirements to be met. This can include traffic management, Quality of Service, over-building/scalability, using equipment that easily allows upgrades and other techniques.

Answer:

Our broadband network will meet the proposed performance tier (speed and usage allowance), latency and (where applicable) voice service mean opinion score (MOS) requirements to be met. Based on the Calix solution set, this includes traffic management, Quality of Service, over-building/scalability, using equipment that easily allows upgrades and other techniques. Details are provided below.

- **Traffic Management/Quality of Service:** Calix has implemented a complete set of advanced QoS techniques to enable our service provider customers to manage bandwidth, delay, jitter, and loss parameters in the network. Voice, video, and critical data applications can be granted priority or preferential service over other best effort applications within the network. It is critical from a service delivery perspective that the integrity of those high-value applications and services remain intact and prioritized and do not degrade in the network. Calix uses advanced QoS toolset (classification and marking, policing and shaping, and scheduling) to enable granular network control and deliver predictable services over a variety of network applications and traffic types.
- **Scalability:** The Calix Intelligent Access Edge systems are designed in a pay as you grow approach. The systems can scale from a single slot (for low first install cost), to multiple chassis (to add subscriber growth), yielding a near linear cost curve. The systems allow for mixing and matching of FTTP cards to maximize fiber access deployment flexibility.
- **Upgrades:** The Calix Intelligent Access Edge systems run on Access eXtensible Operating System (AXOS), designed to provide independent upgrade and verification of modules. Its stateful design means the system continues to deliver services during software upgrades. The Revenue EDGE systems (CPE) likewise run on the EXperience Operating System (EXOS) that enable service provider customers the ability to expand services and capabilities.
- **Diagnostics Toolbox**. The Calix Intelligent Access Edge OLT systems, through AXOS as the underlying platform, offer embedded diagnostic tools to improve operational

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efficiency. Details on the AXOS Diagnostics toolbox are provided in the response to Item 7.

c. For both broadband and voice services, state the target or design peak period oversubscription ratio(s) for the last-mile, middle-mile/backhaul and Internet interconnection that will be used. Additionally, describe the basic assumptions and calculations that will be used in determining these ratios.

d. What general rules-of-thumb will be used to determine if any portion of the network infrastructure needs to be improved, upgraded or expanded to ensure the network is able to meet the required speed, latency and where required voice quality? For example, taking action when (1) when middle-mile link average peak period load is greater than 70%; when a link peak period load exceeds 95% more than 10 times; when a router's average peak period processing utilization exceeds 70%; when an Internet access link load exceeds 75% for a specified time period; when call setup, call drop, call completion rates meet or exceed applicant targets.

e. For fixed broadband wireless access networks, describe how the proposed frequency band(s) and technology attributes, for both last mile and backhaul, will achieve the performance tier(s) and latency requirements to all locations for both broadband and voice services. Specifically, describe how the planned frequency bands, base station configuration, channel bandwidths, traffic assumptions and propagation assumptions and calculations yield sufficient capacity to all the planned locations.

5. Network Buildout: Can the applicant demonstrate that all the network buildout requirements to achieve all service milestones can be met (Yes/No)? The applicant will be required to submit a detailed project plan in the long-form application if it is named as a winning bidder. Describe concisely the information that the applicant would make available in such a detailed project plan.

6. Network Equipment, Consultants and Deployment Vendors: For the proposed performance tier and latency combination(s), can the applicant demonstrate that potential vendors, integrators and other partners are able to provide commercially available and fully compatible network equipment/systems, interconnection, last mile technology and customer premise equipment (CPE) at cost consistent with applicant's buildout budget and in time to meet service milestones (Yes/No)? Describe concisely the information and sources of such information that the applicant could make available to support this response.

Answer:

Yes, we can demonstrate that our vendor's solutions meet the service milestone that are consistent with the performance and budgetary requirements of the proposed buildout. We use the Calix Intelligent Access Edge OLT systems and Revenue Edge premises equipment (CPE) which are carrier-class network and premises systems that are commercially available today,

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offering carrier-class solutions that meet industry standards and provide lasting value to our service provider customers.

- The Calix Intelligent Access Edge systems offer scalable FTTP services through the AXOS platform, with Active Ethernet, GPON, XGS-PON and NG-PON2 solutions successfully deployed in over 250 service providers globally (Source: Calix annual report, 2019). Designed in a pay as you grow approach, our OLT systems enable our service provider customers to scale cost-effectively and future-proof their networks.
- The Revenue EDGE premises equipment (CPE) offers advanced residential gateway systems that provide superior performance and coverage, with a robust SpeedTest solution built to support RDOF compliance based on the Calix Professional Services team's experience with CAF programs.

7. Network Management:

a. Briefly describe the method(s) that will be used to monitor, operate, problem resolution, provision and optimize the network and associated services such as voice. Identify if the proposed solution is internally developed and operated; expands existing systems; uses a third-party network management provider; or is some variant or combination of these methods.

Answer:

We use several methods for network management to monitor, operate, provision, and optimize the network. They include:

- **AXOS Diagnostics Toolbox**. The Calix Intelligent Access Edge OLT systems, through AXOS as the underlying platform, offer embedded diagnostic tools to improve operational efficiency. The AXOS Diagnostics toolbox include the following:
  - **Video Channel Analyzer** improves fault isolation and improve troubleshooting
  - **Local Packet Capture** verifies data delivery and integrity determines problem origin (network or customer premises) to avoid truck rolls
  - **Remote Packet Capture** analysis provides a virtual technician with Wireshark.
- **AXOS Services Management Connector (SMx):** The Calix Intelligent Access Edge systems also use SMx, which provides complete Fault, Configuration, Accounting, Performance and Security (FCAPS) capabilities. SMx is designed to address security, availability, and performance requirements, through a hardened Open Daylight (ODL) open source infrastructure to provide a clustered infrastructure that is designed to meet Tier 1 requirements for high availability, reliability, and security
- **Remote Monitoring Service.** A cloud based, managed service, Remote Monitoring Service helps empower service providers with better visibility and the analytics to rapidly solve network problems that can impact subscriber experience. The solutions will continuously monitor your access network 24x7 for service impacting events. It

automatically filters extraneous alarms while correlating associated alarms to help reduce the average time to resolve and close incidents. Within seconds of an incident, the Remote Monitoring System's intelligent platform will determine the probable root cause using machine learning and pattern matching techniques. It will then send a notification to your operations team with information on the event, alarms involved, problem location, probable resolution paths, and links to additional trouble shooting resources.

All solutions described above apply to the Calix Intelligent Access Edge OLT systems.

b. Remember to include how voice operations will be monitored, operated, problems resolved, provisioned and optimized as appropriate.

c. If the applicant will expand existing network management systems, describe how the current system provides successful operations.

d. If the applicant will use a third-party network management provider, identify any providers the applicant is currently considering.

e. If the applicant will develop, deploy and operate a new system can the applicant demonstrate that it can provide internally developed operations systems for provisioning and maintaining the proposed network including equipment and segments, interconnections, CPE and customer services at cost consistent with applicant's buildout budget and in time to meet service milestones (Yes/No)? If not, can the applicant demonstrate that potential vendors, integrators, and other partners are able to provide commercially available and fully compatible operations systems and tools for provisioning and maintaining the proposed network at cost consistent with applicant's buildout budget and in time to meet service milestones (Yes/No)? Describe concisely the information and sources of such information that the applicant could make available to support these responses.

8. Satellite Networks: If the applicant is using satellite technologies, identify which satellites would be used, and describe concisely the total satellite capacity available, that is, capacity that is not currently in use for existing subscribers.

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