Before the
Federal Communications Commission
Washington, D.C. 20554

In the Matter of	)	
	)	
Modernizing the E-rate	)	WC Docket No. 13-184
Program for Schools and Libraries	)	

COMMENTS OF CCG CONSULTING

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I. INTRODUCTION

1. These are reply comments of CCG Consulting of Beltsville, MD. We are specifically addressing the questions posed in paragraphs 83 and 84 of the NPRM that seek discussion on technologies that can be used to deliver Gigabit speeds into classrooms. Most current wiring technologies cannot handle that much bandwidth for any significant distance. Our comments look at the pros and cons of each existing wiring technology on the markets in terms of the ability to bring Gigabit bandwidth from the Internet connection in a school into the classroom. In particular we will look at a new technology that can deliver Gigabit bandwidth over coaxial cable for greater distances than any competing technology. Finally we will discuss funding for school wiring.

II. SCHOOL WIRING TECHNOLOGIES

2. Getting Bandwidth to the Classroom. As mentioned in the NPRM and widely covered in the news, President Obama announced a ConnectED initiative that has the stated goal of bringing a minimum of 100 Mbps and a goal of 1 Gbps to 99% of students within five years. This NPRM is in response to that initiative. However, since most existing wiring technologies won't deliver 1 Gbps bandwidth very far, one has to ask if we can meet that goal if we only bring a Gigabit to the wiring closet of a school but are incapable of distributing that bandwidth throughout the school and into the classroom? Below I will discuss the pros and cons of wiring schools with various technologies.

3. Category 5 Wiring. Category 5 cable is the most popular technology used for data delivery and has been the standard for corporate LAN and WAN wiring for decades. In ideal conditions category 5 cable can transmit up to 1 Gbps for up to 100 meters (328 feet). It's possible with an Ethernet switch or signal repeater to send the signal an additional 100 meters, although the bandwidth after the Ethernet switch can be significantly decreased due to bandwidth sharing with other devices on the Ethernet switch . Category 5 cabling is a good solution for smaller schools where all of the classrooms are within 100 meters of the fiber termination point. But if schools are not already wired with category 5 cable, it can be expensive to rewire an entire school. Finally, with category 5 wiring an Ethernet router must be installed with each cat 5 cable run being a point-to-point link typically terminating with an Ethernet switch or another Router.

4. Category 6 Wiring. Category 6 wiring is very similar to category 5 wiring, but has additional twists in the copper wire pairs that act to reduce crosstalk and interference within the cable. Category 6 wiring has the specifications that allow it to deliver up to 10 Gbps for up to about 180 feet. But at 100 meters it has nearly the same characteristics as category 5 cabling and can deliver about 1 Gbps. Speeds diminish significantly after 100 meters. Again, for schools not already wired, installing, and provisioning category 5/6 cabling is expensive and requires multiple Ethernet switches and routers.

5. MOCA. MOCA is mostly used in the telecom industry by cable companies to deliver cable signal from the side of the home to the set-top box and between set-top boxes. But the technology can be touchy and generally needs to be professionally installed to work properly. Since MOCA uses the same radio frequency spectrum used by satellite and terrestrial TV, there are potential interference issues when using MOCA for pure data delivery. The MOCA "Application Layer" data rate is incapable of scaling to a full gigabit. MOCA-2 is sometimes touted for being able to carry a gigabit data rate but those numbers are raw signaling rates that rely on high order modulation techniques like QAM-1024 requiring high carrier-to-noise ratios typically unachievable in the real world. The real-world actual delivered 'application layer' speeds are generally a fraction of the 'claimed' speeds and are significantly less than 1 Gbps.

6. HPNA3 and G.HN. This technology is often referred to as 'HomeGrid'. It uses the 5 MHz to 40 MHz portion of the upstream DOCSIS cable modem. This means that HomeGrid can't be used on any system that also carries DOCSIS. So any school that is using the coax to deliver video will not be able to use that same coaxial cable to deliver HomeGrid. HomeGrid will also work over twisted copper wire, but at speeds far slower than 1 Gbps. HomeGrid uses a higher modulation than MOCA, at QAM-4096. This means a very high signal-to-noise ratio which significantly reduces the effective range.

7. Broadband over Powerline – HomePlug. HomePlug delivers bandwidth over existing electrical cables and is referred to as broadband over powerline. It is potentially capable of delivering significant bandwidth but there are many real world problems with deploying the technology. Powerline channels are subject to a great deal of variation at any given instant. Air conditioner compressors, fans, inductive heaters, lighting ballasts and motors all change the impedance of the powerline in a highly variable dynamic manner as each of these devices are used on and off throughout the day affecting the powerline network. Additionally, unlike with coaxial cable where the cables are similar from location to location, broadband over powerline is going to vary widely in performance depending upon the gauge, age and condition of the electric wires it is using. Even within one room there are often different wire sizes, meaning that performance is going to vary in terms of data speeds, jitter and overall reliability. This technology is incapable of delivering Gigabit data rates at the 'application layer'. Even at lower data speeds it is impossible to provide consistent quality-of-service or consistent data rates due to the variability.

8. WiFi. The newest version of WiFi (802.11ac) is designed to support raw data rates up to 7 Gbps compared to today's WiFi that tops out at 600 Mbps over short distances. WiFi operates in both the 2.4 GHz and 5 GHz spectrum bands. There are significant challenges associated with using WiFi as a substitute for wiring. WiFi is ideal for delivering bandwidth for a short distance, but the bandwidth degenerates with distance quickly and is greatly diminished by passing through a wall or other impediments. Probably the greatest challenge of solely using WiFi to network and distribute data is that WiFi Access Points are dependent on wired data connections to provide the broadband connection. WiFi is not a data backbone technology. It is best used in conjunction with a wired data backbone that is capable of supplying hundreds of Megabits of data capacity and is best when used to provide the last 50 feet of network connectivity.

9. WiGig - 60 GHz Wireless. The new 802.11ad WiFi standard is being touted to deliver up to 7 Gbps. It will not pass through walls, or even wallpaper, so it is not a wiring solution for schools. But I mention it due to the fact of the speed it can carry. If this technology is ever made commercially available it would be a great way to deliver bandwidth within a classroom. But there has been talk of almost having a market ready 60 GHz product since 2007. There are several big hurdles to overcome. It's power consumptive and requires big heat-sinks to keep cool. It also has an issue with emissions. The spectrum can radiate up to 10 Watts with the

spectrum mask currently in place for indoor operation. That's potentially 1/10 the power of a microwave oven radiated at all times, which is the ionizing radiation of 10 Watts at 60 GHz. And of course WiGig has the same limitations of traditional WiFi in that it must depend on a wired data connection at the Access Point to provide the bandwidth for the wireless connection.

10. PulseLink Ultra Wideband. Our firm recently tested a new technology developed by PulseLink of Carlsbad, CA. PulseLink has developed a technology capable of utilizing the radio frequency (RF) spectrum on coaxial cable above 2 GHz and can deliver data rates exceeding 1 Gbps. They are marketing the technology under the name of CWave. This technology uses a wide swath of RF spectrum in the 3 to 5 GHz range. As a result the RF signal is out-of-band (OOB) to both Cable TV and Satellite and will peacefully co-exist with both. Typically RF spectrum above 3 GHz on coax cable has been considered unusable RF spectrum, but due to the unique techniques used by Pulse-LINK's CWave chipset the technology reliably delivers Gigabit data rates while not disturbing existing frequencies used by cable TV and cable modems. Effectively it adds a whole new Ethernet data path over existing coax using existing wiring and provides a school wiring solution that needs no new wires. Below is a chart that compares the bandwidth that can be delivered by each of the technologies listed above. As you will see, only PulseLink can deliver a significant amount of bandwidth over 100 feet.

11. Since the vast majority of schools are already wired with coaxial cable to the classroom to support TV, using that same coax cable to deliver high data rate networking is a tremendous money saver. Wiring schools from scratch is an expensive undertaking while upgrading with the PulseLink CWave can be done quickly and inexpensively. This may alleviate a lot of the concern expressed in the NPRM about funding inside wiring.

12. Comparative Speeds of Different Technologies. Following is a chart that shows the relative speeds over various distances of the technologies discussed above. I think a side-by-side comparison is an easy way to see that existing technologies are inadequate for bringing gigabit bandwidth to anything other than small schools. But since many schools have rambling campuses and multiple buildings, only a technology that can deliver bandwidth for longer distances is going to be adequate to make sure that the bandwidth delivered to the wiring closet of a school ends up in the classrooms. One has to ask the question if it makes any sense to try to bring large bandwidth to the schools without a technology like PulseLink that can get it to where it is needed. Otherwise the Gigabit speeds would be more for publicity than practical use.

13. The chart is based upon the 'application layer' speeds. These are the speeds that are generally widely published and thus make for the easiest relative comparison. But for various reasons such as overheads and signal to noise ratios, each technology is going to deliver speeds slower than the application layer speed.

Wired	10 Feet	100 feet	300 feet	500 feet	1000 feet
Category 5 Wire	1 Gig	1 Gig	100 Mbps	X	X
Category 6 Wire	10 Gig	1 Gig	100 Mbps	X	X
MOCA-2 (2 Bands Bonded)	~800 Mbps*	~800 Mbps*	~400 Mbps*	X	X
HPNA3 / G.HN-"HomeGrid	~1 Gig*	~1 Gig*	Unknown	X	X
HomePlug	~400 Mbps*	~100 Mbps*	~20Mbps*	X	X
Pulse-LINK / CWave (2 Bands Bonded)	2 Gig	1.6 Gig	800 Mbps	400 Mbps	200 Mbps

Wireless					
802.11 ac (2.4/5 GHZ)	~1Gig*	<100Mbps	<10Mbps	X	X
802.11 ad (60 GHz)	~3.5 Gig	X	X	X	X

Data Rates are for 'Application Layer' throughputs.
* Estimated

III. Paying for Rewiring

14. Should the USF Fund pay for school wiring? I am not sure that USF funds should be used to rewire schools with technologies like category 5 wiring. The cost to do so is significant, particularly for larger schools. It makes no sense for the USF fund to fund wiring (which can be quite expensive) if that wiring is going to deliver speeds that are significantly slower than the Gigabit speeds that will be delivered to the school. When the ConnectED program talks about bringing Gigabit speeds to a school, the goal really is to bring that much bandwidth to the classroom. Getting carriers to deliver 1 Gbps data pipes to schools is going to be expensive and will make no sense if we are unable to get it to the classroom due to the limitations of the wiring at the school.

15. However, I can’t see any problems with allowing for USF funding for technologies that will deliver most of the bandwidth to the classrooms. In small schools this might mean category 5 wiring, but in large schools it will require some different technology like the PulseLink CWave. I recommend that we only fund wiring in the cases where the school can certify, through some sort of test, that a large portion of the bandwidth delivered to the school is making it to the classrooms.