



# The Internet's Third Act: The Connected Device Decade

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***From Smart Phones to Smarter Everything:  
How the next wave of connected devices will further accelerate mobile opportunity,  
and further exacerbate the looming spectrum crunch.***

## I. Introduction

The United States is on the verge of a vast new spectrum-driven technological revolution with the power to transform our economy, our lives, and the way we do business. This revolution is being driven by breakthrough technologies connecting us to the world around us through a vast sea of smart connected devices. Trillions of transistors, billions of sensors, and the growing ubiquity of fast wireless data connections are helping to fuel this technological transformation filled with astonishing new digital opportunities.

Several technology trends are rapidly converging to drive this new opportunity – the cost of connecting devices is falling, computing firepower is rising, and the value of connectivity is increasing. As a result, experts predict that by the year 2020 there could be an astounding 50 billion devices connected to the Internet.<sup>1</sup> The enabling technology that is making it all happen is called Machine-to-Machine or M2M. These M2M applications are already embedding intelligence, sensors, and servos into the physical world around us -- making businesses more productive, transportation more efficient, and our world more connected.

But the real story of this unfolding chapter is not just about connecting devices to the Internet, it's about connecting people to new opportunities that can improve their lives. It's about someone with a chronic medical condition whose doctor can be automatically notified by a wireless sensor if their medical condition changes; it's about cars that can automatically call for help after a crash to speed life-saving help to the scene; and it's about boosting our productive capacity again – the essential ingredient for growing our standards of living.

This smart revolution is spreading from the palm of your hand to your home, your car, your work, and everything else around you. Soon, the same technologies that have made our phones smart will also make our homes, cars, and workplaces smarter. Not just smarter, we're talking genius. Computing intelligence will be infused deeper into the very systems and processes that make the world work—into things no one would recognize as connected computers: from power meters, trucks, containers, cars, pipelines, web-connected home appliances, wind farm turbines, vending machines and almost any

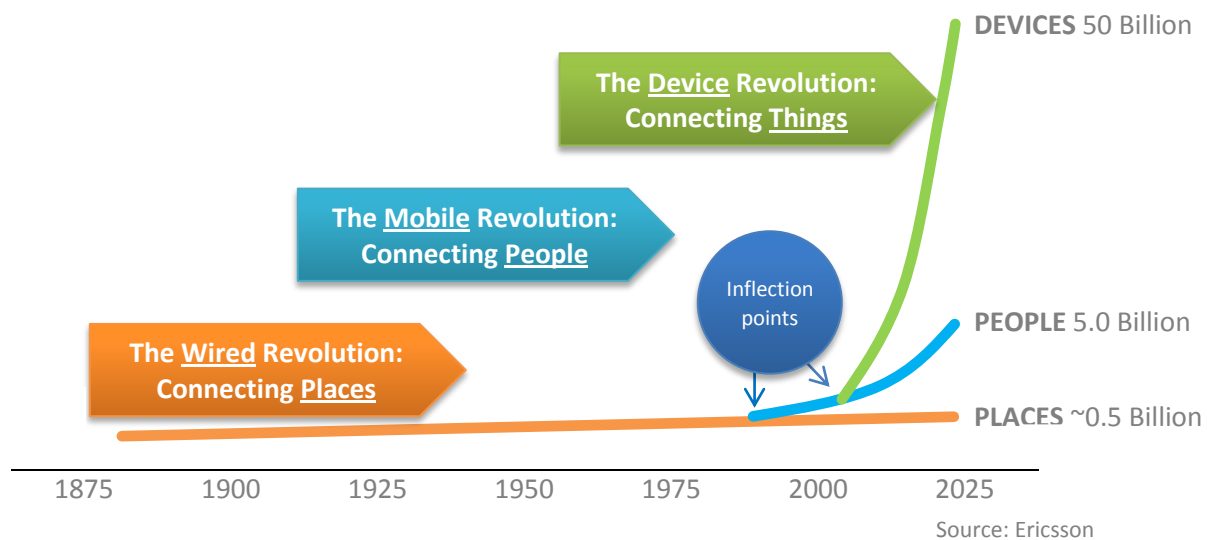
*“Moving forward, we won’t just be talking into our devices, they will increasingly be talking to each other. With machine-to-machine technologies, cars will be equipped with sensors that can automatically take evasive action to avoid accidents. People with chronic disease will have wireless devices that notify doctors about a sudden change in condition. When an accident causes major traffic delays, your alarm clock will be notified to wake you up early so you’ll get to work on time. This isn’t science fiction. This is here and now.”*

– FCC Chairman Julius Genachowski

electronic device that can benefit from two-way communications. Doing so will help enable smarter ways to grow our economy, protect the environment, improve public safety, and raise our standards of living.

Think about the massive impact that the wireless industry has had. Today the mobile sector – including everything from applications developers, device makers, and service providers—supports 2.4 million American jobs and contributes \$100 billion annually to the U.S. GDP. It has created thousands of new jobs, industries and opportunities almost overnight. Now multiply that again. The proliferation of connected devices is projected to create \$1.2 trillion in economic activity by 2020 – unleashing a new wave of job creation as mobile technology is implanted into everyday things.<sup>2</sup> And every new dollar invested into wireless adds \$10 to the U.S. GDP.<sup>3</sup>

## Anything that can benefit from connectivity, will be connected to the Internet



This will be the Internet's third – and perhaps most significant – transformation. Over the last several decades, we have witnessed two amazing digital transformations. The digital age began with a wired revolution that sought to connect places – like businesses, homes, and schools to the Internet. Then with the advent of mobile data connections, a second revolution driven by cell phones enabled us to connect people, not places – enabling anytime, anywhere access to e-mail, and applications. Now we are on the verge of the third phase of this technology trifecta — as we connect an amazing array of things to the Internet – virtually anything and everything that can benefit from being connected. At every inflection point in this transition, consumers have benefitted from the massive new opportunities



and jobs created. As we cross a new inflection point, connecting physical things to the online world is likely to spark a digital device deluge even more transformative, even more pervasive, and even more consequential than past revolutions that merely connected places and people.

This digital device decade can herald significant societal benefits. If comprehensively deployed in a variety of ways throughout sectors of the economy, studies suggest that connected devices, along with other IT advancements, could help:

- Reduce carbon emissions by 25%<sup>4</sup>
- Reduce crime by 20%<sup>5</sup>
- Cut traffic jams by 20%<sup>6</sup>
- Cut fuel consumption by 20%<sup>7</sup>
- Reduce accidents by 40%<sup>8</sup>
- Cut traffic fatalities by 20%<sup>9</sup>
- Add \$1.2 trillion in job creating economic activity<sup>10</sup>

However, the extraordinary growth of wireless connected devices is combining with already explosive smartphone growth to quickly exceed the available wireless spectrum, the invisible infrastructure that powers this mobile ecosystem. If we don't allocate more spectrum for mobile connectivity, our nation's appetite for wireless could out-strip capacity as soon as 2014, and the vast benefits from M2M devices will be delayed. This paper looks at the amazing opportunities that can come from the digital device decade ahead, the technologies that are driving it, and the pragmatic policy choices for enabling this brighter future beginning with making more spectrum available.

## II. Transforming Vital Sectors Of The Economy To Enable A Smarter World

**Connecting Everything.** Innovation is quickly moving from the smart phones in our hands, to the genius devices connecting our world. These devices are taking everyday things and making them infinitely better. Already, there are vehicle accident reporting devices, mobile payment systems, remote health monitoring devices, smart utility meters, connected refrigerators, picture frames, pill bottle caps, traffic lights, and parking meters that use mobile technology to streamline our lives. These devices are poised to transform virtually every sector of the U.S. economy—from transportation to health care, from energy to consumer electronics.

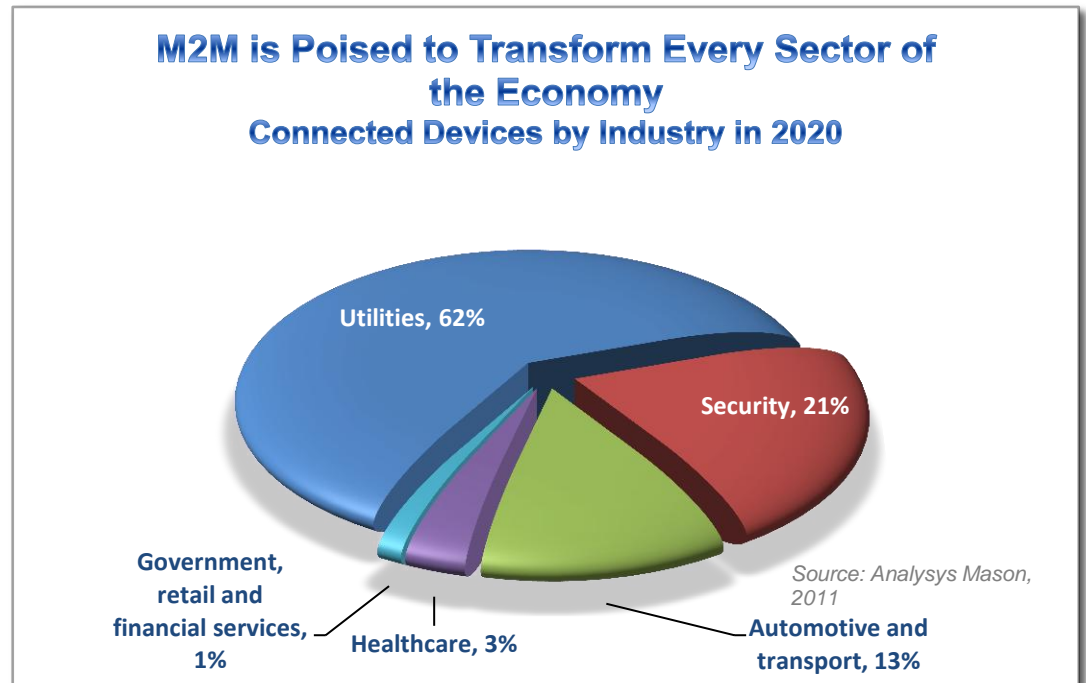
## A. Smarter Transportation

Our nation's infrastructure – its roadways, railways, and runways – were often not designed for the 21<sup>st</sup> century nor to efficiently handle the growing demands we place upon them. As a result, Americans waste an average of 34 hours each year sitting in traffic (4.8 billion hours combined), unnecessarily lose thousands of lives on

highways each year, waste 3.9 billion gallons of fuel and produce millions of tons of avoidable pollution.<sup>11</sup> Fortunately, the combination of smarter infrastructure and smarter vehicles is poised to vastly improve our daily lives by making cars smarter, accidents less frequent, parking even easier, crashes more survivable, delivery more dynamic, and commutes more efficient. In fact, some of the earliest M2M applications came in the transportation sector. This sector accounts for the largest number of connected devices today – from the systems that can track the real-time location of vehicles and the goods they are delivering, to the systems in your car that can automatically call for help if you are in a crash.

Wireless connectivity is revolutionizing how we get from here to there. It is transforming:

- **Telematics systems** that can connect you and your car to roadside assistance for a flat tire, empty gas tank, or to automatically call for emergency help in the event of an accident;
- **Vehicle theft tracking services** that can help you sleep well knowing that you can track your car if stolen, and shut it down if needed;
- **Onboard engine diagnostic systems** that continuously monitor oil pressure, tire pressure, and electronics in order to send a text message or notice for preventative maintenance needed to avoid bigger problems from occurring;
- **Connected onboard navigation systems** that forewarn of traffic back-ups, and get you to your destination faster and easier; and
- **Infotainment systems** that keep you connected with news, weather, and entertainment for the ride.



It's not surprising these are popular services. Over the past 15 years, more than 5.6 million people who have locked themselves out of their cars have taken advantage of a connected car to remotely unlock the car.<sup>12</sup> But we are just at the beginning of what may be possible as cars, bridges, roads, and traffic lights are connected with 3G and 4G services. The introduction of smart cars and smart roads represents the biggest transportation transformation since Henry Ford cranked up his assembly line, and Dwight Eisenhower began building the Interstate highways. While only 5 percent of cars are wirelessly connected today, in three to five years nearly all new cars will be connected.<sup>13</sup> Already a variety of vehicles include connectivity options like the Audi connect, BMW ConnectedDrive, MyFord Touch, MyLink from GM, UConnect from Chrysler, Entune and Touch & Go from Toyota, Hyundai Blue Link, Nissan LEAF's connected mobility, and Cadillac CUE (Cadillac User Experience).<sup>14</sup> These systems can have a tremendous impact – saving lives, reducing accidents, speeding your commute, and remotely connecting your mobile device to your car. And we are just at the beginning.

**Saving lives.** Wirelessly connected telematics systems, one of the first and most effective applications, are now helping enable faster emergency response when cars get into accidents. Each year, there are more than 6 million crashes that occur on U.S. highways killing 41,000 people. Advanced automatic crash notification (AACN) systems are designed to automatically call for help when an airbag is deployed – reducing crash notification delay, while also providing other life-saving data to emergency responders over wireless connections like crash speed, the number of vehicle occupants, whether they were wearing seat belts, and roll over information.<sup>15</sup> The National Highway Traffic Safety Administration (NHTSA) estimates that collision notification systems could reduce fatalities by as much as 20%.<sup>16</sup>

**Reducing accidents.** Connected car devices can also help to improve poor driving, and reduce accidents before they happen. For example, Quartix has developed a monitoring and reporting tool that gives drivers feedback on their driving such as inappropriate acceleration, speeding and quick braking. Likewise, DriveCam provides real-time driving analytics to help drivers stay on their game, and fleet operators to stay ahead of the causes that lead to poor driving.

**Connecting cars to each other.** Soon, smart cars may talk to each other too, making cars even smarter and traffic accidents less frequent. In conjunction with Toyota, Italian researchers are testing software on Los Angeles streets and freeways that lets cars communicate with each other. By letting a car know what is happening ahead of them, they estimate it could reduce accidents by as much as 40%.<sup>17</sup> In the short-term, companies like BUMP are using automatic license plate recognition technology to look up communication channels for vehicle to vehicle communication.<sup>18</sup> To help make cars more enjoyable to drive, companies like Teleca are working to integrate a variety of Internet connected location based services into a simple, elegant nerve-center within the car.

**Accessing your car from your phone.** Wireless connected technologies are also enabling you to remotely connect to your car. With the advanced features that come from a connected car, companies like Agero offers services that let you check your gas gauge, car temperature or oil pressure from the convenience of your desktop or smartphone. Similarly, ZipCar allows you to reserve a car, locate it, honk the horn, and lock or unlock the car – all with an iPhone app. And if you want to go green, AT&T innovators are connecting Ford Focus electric vehicles so you can keep track of and schedule charging,



while also connecting you with status notifications, range information, and nearby recharging station locations.

**Making parking easier.** Connected devices are also taking the headache out of finding open parking spaces. For example, T-Mobile has launched a wireless parking meter that senses when an automobile has left a parking space, and then sends data to a smart phone application that shows where open spaces are available. When you park at a meter or in a garage and find you are out of quarters, other connected technologies allow you to pay to park with your credit card or smartphone by enabling the meter to communicate wirelessly to authenticate payments. ParkNOW, for example, allows cell phone users to communicate with thousands of parking meters to pay for parking in the suburbs of Washington D.C. They claim that cash handling and payment infrastructure costs for cities can be reduced by 70 percent.<sup>19</sup> Other companies also use cellular technologies embedded in meters to enable remote credit card authorizations – like parking meters made by IPS Group and Digital Payment Technologies who use wireless technology to provide real-time credit card authorizations and meter status reporting.

**Quickening commutes.** And for those who commute to work by bus, train or subway, new connected vehicle trackers have enabled a new generation of smartphone apps that allow passengers to track commuter buses and trains in real time. In Boston, for example, the transit authority estimates that during peak periods as many as 100,000 people use the dozens of tracking apps for buses and subways including Track My Transit, Open MBTA and BusMinder.

**Making package delivery more efficient.** FedEx and UPS have significantly boosted their productivity and given consumers vital information about the location of a package by using connected scanners to track packages and vehicles. Now multiply that as the entire U.S. supply chain of goods and services gets smarter by taking advantage of location based services to track vehicles and goods in real-time. One business, for example, was able to recover more than \$1 million in stolen goods when an M2M sensor registered excessive shock (high g-forces that typically are a sign of theft) and enabled the police to track its location.<sup>20</sup> Developments in communication technology mean it will soon be possible to track goods down to their pick-up or drop-off locations, and even confirm delivery or pay on-site. FedEx has started “thinking inside the box” and has developed a connected device called SenseAware that drops into a package to transmit location, temperature, humidity, barometric pressure, and exposure to light – which could reveal if the package was prematurely opened or tampered with.<sup>21</sup>

### Tracking Endangered Species and Unlocking the Mysteries of the Wild.

In order to unlock the mysteries of the wild and track endangered species, smart collars may fundamentally transform what we know, and how we manage animal populations. Scientists are developing devices that include GPS to track migration and location; accelerometers to monitor sleeping habits and activity level, and sometimes even cameras to watch the animals’ environment and see what they see. Already, smart tags have helped track endangered Imperial Eagles in the Balkans.



**Improving fleet management.** Companies like Telit are building smart sensors and M2M devices that are also becoming an important mainstay in vehicle fleet and asset management systems where freight needs to be delivered rapidly, and where driver and vehicle monitoring is essential for improved efficiency and safety. There are now over 2.1 million fleet management systems deployed in commercial vehicle fleets in North America, and they are projected to reach 3.8 million by 2015,<sup>22</sup> helping businesses reduce costs and improve efficiency. These connected devices often allow businesses to monitor vehicle location remotely, track driver speeds, and run diagnostics on the engine to identify vehicles in need of maintenance. In some cases, companies that have deployed M2M enabled fleet tracking systems have started giving feedback to drivers. The results have shown an improvement in driving and a drop in the number of potentially hazardous maneuvers – in one case there was a 49% reduction in accidents.<sup>23</sup>

## **B. Smarter Energy and a Better Environment**

Emerging wireless-enabled devices have the potential to drive billions of dollars in energy savings in a range of American industries, while also improving the environment. These digital devices are enabling us to use energy more efficiently in the electric grid, in buildings, in our homes, on the farm, in our factories, and throughout our environment.

By enabling utilities to wirelessly connect to circuit breakers and meters, smart grid technology is helping businesses and consumers cut their energy use while advancing an intelligent, resilient and self-balancing utility network. Real-time data from smart meters is also helping utilities monitor use and tackle energy efficiency. It's one of the reasons why the energy sector is one of the fastest growing M2M segments. In fact by 2020, the utility sector is expected to make up 62% of M2M connected devices.<sup>24</sup>

Building owners aren't far behind. Device and sensor developers are working to arm building managers and tenants with the information they need to make the best decisions possible about their energy use. Soon, smart buildings outfitted with an array of sensors that monitor motion, temperature, humidity, occupancy, lighting, ovens, gas pumps, and other equipment, will not only help

### **Powering Our Future, Improving Our Environment:**

- Fully utilizing smart traffic technology could cut fuel consumption on urban roadways by as much as 20 percent.
- By harnessing sensors to improve and expand application of precision agriculture could reduce water use by 11 to 50 percent.
- The number of M2M connections in the utilities industry is projected to grow from 100 million in 2010 to 1.5 billion by 2020, of which 99% will be smart meters.
- Wireless smart grids could eliminate 360 million metric tons of CO<sub>2</sub> – the equivalent to the annual energy use of 30 million U.S. homes.
- If the U.S. fully utilized a smart grid, we could cut carbon emissions 12% by 2030, equal to the output of 66 power plants, according to the Department of Energy's Pacific Northwest National Laboratory.



reduce a structure's carbon footprint, it can give a real-time look at a building and all the systems inside to ensure maximum performance and profitability. If a pipe bursts, or a freezer fails while no one is at a retail store, sensors could detect the problem and dispatch a repairman before problems turn from bad to disastrous.

With transportation sources attributable for roughly 40% of all greenhouse gas emissions, connected devices are also helping route trucks more efficiently to save fuel and cut emissions. Communities that fully utilize smart traffic technology could cut fuel consumption on urban roadways by as much as 20 percent.<sup>25</sup>

At home, smart devices can also help the pocket book. From smart plugs that control energy consumption for appliances, to connected thermostats that can be controlled remotely, to systems that can tell you which light was left on and allow you to turn it off, or the ability to run your dishwasher from your smart phone – smart devices are helping manage our homes and cut energy costs. Lighting alone consumes about 12-15% of home energy bills, and 50% of lighting is wasted on empty rooms – a problem that connected devices in a home automation system can quickly fix.<sup>26</sup>

Their use is growing on the farm too. With the help of moisture sensors in the ground, and connections to online weather services, irrigation systems can now check the ground and monitor the weather for smarter watering, reducing runoff, and better water conservation.<sup>27</sup> Studies have found these sensors can reduce water use by as much as 20%. Other types of farming devices can monitor temperature, humidity, precipitation, solar radiation, and wind speed – providing an early warning system for the conditions that can lead to costly crop killing fungi or frost.

Connected devices can also improve our ability to monitor our environment in the world around us. For example, the National Science Foundation is creating a national observatory network of mobile sensors to collect data across the United States on the impacts of climate change, land use change and invasive species on natural resources and biodiversity. This new network, called the National Ecological Observatory Network (NEON), will include 100 tracking towers, 30 aquatic sites, and 3 air-borne platforms; can determine concentrations of carbon dioxide, methane and other gases; and will monitor environmental conditions and make it publicly available to other scientists and policymakers.<sup>28</sup>

For environmentalists, one of the most promising uses of connected devices is for a variety of animal cams that can track and display real time video of an endangered species habitat – like hatchlings in a Bald Eagle's nest, panda cubs, or on an undersea journey following an endangered sea turtle.

### **C. Smarter Business**

When machines talk, businesses listen. The ability to automatically collect data, wirelessly transmit the data and accept electronic instructions from a distant mobile supervisor can be transformative for businesses both big and small.

Now industrial devices are being connected and controlled remotely from smart devices like iPads – improving agility, intelligence, efficiency and control. With a relatively small investment, manufacturers



are often finding they can control machines, get real time alerts on potential equipment failure, navigate huge warehouses with the flick of a finger – and in the process gain new efficiencies and cost savings.<sup>29</sup> Mobile devices can enable a company to:

- Employ a real-time inventory system that can identify the current location of all products, parts, tools, vehicles and equipment – and order new inventory before running out
- Remotely and continuously capture and analyze machine performance data
- Utilize captured data to further improve product design
- Preemptively initiate and manage repairs and upgrades before they become disastrous or more costly – reducing down time

With such an amazing proliferation of devices and protocols, companies like Candi Controls have developed technologies that can connect and manage connected devices regardless of platform, protocol, environment or manufacturer. And to help businesses, consumers and service providers better manage a multitude of wireless devices, companies like Amdocs are helping companies to make billing simpler, activation quicker, devices more secure (through network authentication), problem resolution faster, and over-the-air firmware and application updates more automatic.

#### **D. Smarter Payments**

One especially powerful connected device application is new point-of-sale services that can create new business opportunities, give consumers more choices, and create new pay-as-you go business models. Point-of-sale technology is already employed in vending machines and some card payment systems.

ATM machines are one of the earliest examples of connected M2M technology. But now, personal payment systems can happen anywhere with a phone. For example, a SIM card embedded into a Coke vending machine can communicate with the soft drink company to let it know exactly how many cans have been sold and how many are left in the machine. This information can be used by the company to manage its inventory control systems more efficiently. Other devices can attach to an iPhone or iPad to enable proprietors of the corner lemonade stand to take credit cards.

With the help of new technology, the mobile phone could eventually take over your wallet, replacing your credit cards, cash and coupons. Soon customers will be able to use Near Field Communications (NFC) technology built into their mobile phones to pay for goods and services at vending machines, rental kiosks, and a variety of new devices that wirelessly connect. The technology is set to be a key facet in the emerging mobile payment revolution, currently under development by the likes of companies like Google, PayPal, T-Mobile, and Visa among others. And companies like BilltoMobile, Venmo and Square are becoming mobile payment powerhouses as they develop new ways to incorporate payment platforms into mobile devices. These types of breakthroughs can enable entirely new business models for products and services by enabling pay-per-use, on-demand, and other payment methods for connected devices that can authenticate transactions.

## **E. Smarter Homes**

Whether at home or away, smart connected devices inside and around the home are giving us greater control over our lives. Already, everything from washing machines, refrigerators, light bulbs, thermostats, and digital photo frames are being connected wirelessly in the home. Wireless devices are on the market to connect remotely your sound systems, security, lighting, door locks, thermostats, fire sensors, watering systems, and intrusion detection systems. Soon, almost any device in your home can be an accessory for your smartphone. It's happening so fast that by 2014, 70% of all consumer electronics are expected to be wirelessly connected to the Internet.

To further boost this smart home opportunity, Google, for example, unveiled the Android@Home framework, a set of protocols for controlling light switches, alarm clocks and other home appliances through any Android device. And there are already dozens of home automation apps for the iPhone that allow you to control smart devices throughout your home. These technologies are becoming so pervasive around the house that some have even suggested that your next home is itself likely to be so crammed with servos, sensors, and connected devices that the home itself will be a robot.<sup>30</sup>

Even though it's still just emerging, analysts predict this home automation field is about to explode – increasing from 1.8 million systems to 12 million systems a year within five years.<sup>31</sup> The technology is growing in popularity because of its convenience, the savings it enables, the home security it delivers, and the energy conservation it brings.

## **F. Smarter Security**

One of the most popular forms of connected devices involves those deployed in smart home security systems. They often integrate wireless devices into your home to enable remote intruder detection and image streaming to your cell phone over a combined security platform which can be remotely controlled from your mobile device. By 2020, there are projected to be almost a half a billion connected devices in the security sector alone.<sup>32</sup> Companies like Alarm.com are taking advantage of wireless networks to let you arm or disarm your systems remotely, to watch live video, detect water in a basement, trigger real-time e-mail or text notifications, and control critical systems like lights, thermostats, locks, and small appliances remotely.

There are even robot sentries making their way to market that can be remotely controlled over mobile networks like the Spybot which allows you to stream live video as the robot patrols your home while you're away.<sup>33</sup> iRobot, which makes millions of vacuuming robots and military robots, is launching Ava which uses an Android or iPad for its brain, eyes, ears and communication. The partnership is aimed at fostering new connected robotic applications.<sup>34</sup>

These M2M connected robots are already enabling people to live fuller lives. For example, Lyndon Baty – a 15-year old boy in Texas – uses a robot avatar to go to school for him because exposure to even the slightest virus can kill him.<sup>35</sup> Even though he lives in isolation at home, now a four foot tall PC controlled wireless enabled robot with a live video feed displaying his face can go to classes, wander the halls, and enable him to carry on conversations.



## **G. Smarter Cities**

But the bigger security improvements from connected devices may occur outside our homes – from the new connected devices being deployed throughout our communities. In more than 500 cities and towns in 25 states, silent sentries with wireless connections and unblinking eyes keep watch over intersections, snapping photos and shooting video of drivers who run red lights.<sup>36</sup> Not without their critics, more than a dozen large studies over the past decade have concluded that these connected camera systems reduce accidents, crime, and injuries.<sup>37</sup>

Red light and speed cameras now have a family of siblings that often sit on utility poles to watch over high crime neighborhoods. This broader set of wireless surveillance cameras can lower crime rates and make people safer. Nowhere have they been used as pervasively as in the United Kingdom which has deployed 4 million cameras throughout the U.K. and more than 1 million active in London alone.<sup>38</sup> But some U.S. cities are beginning to catch up. In Chicago, there are now more than 2,000 government-operated connected cameras pointed at streets, transit stations, housing authority properties, and critical infrastructure installations around the city. When privacy and other issues are addressed, studies have found that surveillance cameras are a cost-effective deterrent to crime. Baltimore's network of more than 500 cameras have been found to have driven down crime in most areas and has given taxpayers a return of as much as \$1.50 for every dollar spent on the system.<sup>39</sup> For police, connected devices act as force multipliers, as mobile fingerprint readers and surveillance cameras. The effectiveness of the cameras can also be multiplied by piggybacking them with audio surveillance systems that triangulate and pinpoint the location of gunshots in real time, and automated license plate recognition (ALPR) systems that passively record the license plates of every vehicle that passes within their view. In Washington D.C., scores of cameras throughout the city with license plate recognition capabilities capture 1800 images a minute helping police pinpoint stolen cars and fleeing suspects. It's Joe Friday meets George Jetson. Wireless surveillance is also an area where policymakers must still address important privacy and civil liberty issues, but the commensurate benefits achieved from broad deployments could be vast.

Smart devices can also improve our ability to get around. If you have ever crept red light to red light through traffic, you understand that our traffic system can be made smarter and more effective too. Every day, traffic congestion cuts into worker productivity, delays deliveries, guzzles gas and increases air pollution. Connected devices can be a congestion buster – linking roadside sensors that measure traffic to synchronized traffic lights, digital road signs, and in-dash navigation systems that guide drivers to the faster routes and improve traffic flow.

Many traffic light systems are 30 to 40 years old – deployed before the benefits of networking were well understood. But as roadside sensors have become more pervasive and able to make more informed decisions about traffic flow, now traffic lights can be connected and synchronized so that cities can create intelligent transportation systems that cut travel times and reduce fuel consumption. Based on trials, BMW estimates smarter connected traffic systems could cut urban fuel consumption by 10 to 15 percent.<sup>40</sup>

Likewise, IBM is developing software that uses data from connected sensors to predict traffic jams before they form – as much as 45 minutes in advance. This data can be used to adjust traffic lights and warn drivers. The system, being tested in Singapore, has proved to be about 90% accurate in predicting the volume and speed of drivers in the central business district – information that is then used to adjust 1,700 sets of traffic lights to improve the flow of traffic.

When taken together, these technologies can help build smarter cities. By increasing the technology embedded in city processes and infrastructure, IDC estimates that it's not impossible to see:<sup>41</sup>

- Reduction in carbon emissions of 25%
- Energy savings of 50%
- Reduction in crime rates by 20%
- Reduction in traffic jams of 20%

## **H. Smarter Health Care and Patient Monitoring**

Doctors are poised to see some of the biggest health care advances since the invention of the x-ray. Wireless innovations have the potential to dramatically enhance the quality of healthcare, improve health outcomes, lower medical costs and expand the reach of our medical system. They can connect doctors with real-time remote bedside data – whether across the street or across the country – and connect patients to care anytime anywhere. These mobile marvels can help overcome some fundamental barriers that can make the delivery of care inefficient, fragmented and at times impossible. And they can connect consumers with new ways to stay fit and healthy.

Today, a shortage of healthcare professionals is making it more difficult to care for a growing U.S. population. That is why many doctors are particularly excited about the opportunities to improve care and extend service with mobile tools. Connected devices are helping to improve access to real-time medical information, becoming an integral part of patient care, helping to provide more cost effective healthcare management and saving lives. Remote-monitoring solutions can sense, monitor, and measure blood pressure, glucose, cholesterol, weight, and other vital signs and allow patients to transmit the data to the cloud, physicians, or loved ones.

For example, half of Americans forget to take prescription medicines at the appropriate time, but connected bottle caps use light and sound to remind patients to take medicine and can alert a loved one if the patient forgets in order to help people stick to a prescription regimen.<sup>42</sup> Today, 6 out of every 10 people who suffer from Alzheimer's or dementia will wander. Now wearable devices can help locate patients if they get lost.<sup>43</sup> Likewise, connected asthma inhalers let doctors track the frequency and location of asthma attacks to better treat patients. And smart bandages can monitor vital signs and transmit that information wirelessly.<sup>44</sup>

This is what people want. Nearly 8 of out 10 Americans are willing to pay up to \$100 for a medical device that monitors their vital signs.<sup>45</sup> As the U.S. continues to face shortages of critical care physicians, cardiologists and critical care nurses over the next 5 to 10 years, the U.S. market for remote patient



monitoring is expected to grow about 25 percent per year – from a \$7.1 billion market today to a \$22.2 billion market by 2015.<sup>46</sup>

Connectivity can make a difference within hospitals too – saving lives and money. For example, by deploying a suite of connected devices to better monitor patients, the patient mortality rate at Virginia-based Sentara Healthcare dropped 25 percent, length of stay in the ICU fell by 17 percent, and per patient costs on reduced expenses and increased ICU capacity went down about \$2,150. To help advance solutions like these, Alcatel-Lucent is currently engaged with the University of Pittsburgh Medical Center in the development of several connected medical devices including a digital stethoscope, to create what amounts to a “virtual exam room” so patients can receive medical care from any location at any time through a variety of mobile devices.<sup>47</sup> And technologies like eCardio Diagnostics provide near real-time tracking of cardiac patients, enabling them to recover at home rather than spending additional time in hospital.

But some of the biggest leaps for improving health will come from devices that have yet to be invented. That is why some people have called for a “moon shot” goal for the development of connected health devices<sup>48</sup> and the X Prize Foundation and Qualcomm are co-sponsoring a \$10 million award for the best mobile device allowing consumers to diagnose their own diseases.<sup>49</sup>

For consumers who want to stay healthy, connected devices can also be a boon to preventative medicine – helping improve people’s lives, fitness, and in some instances avoid the high costs of emergency room visits. Millions of people have downloaded calorie-counting apps for their smartphones, and soon a new breed of motivational devices may help people follow a diet, stay on an exercise program, or quit smoking or drinking.

One especially exciting growth areas is in connected body monitors, which are enabling new ways to monitor vital data for everyone from firefighters to seniors; and from athletes to infants. For example, connected devices are helping athletes track fitness goals in real-time, monitor heart rate, distance, and altitude gained during a bike ride or run. Wireless sensors are also being used to monitor firefighter temperature so a captain can radio if a firefighter gets too close to the fire.

New parents have also benefitted from the connected device revolution and are now often turning to next generation baby monitors that allow parents to monitor real time video as well as the vital signs and the physical conditions of their child from a cell phone. For parents worried about sudden infant death syndrome, a pair of pajamas made out of a fabric-based biosensor material can communicate with a cellphone or PC via a home’s wireless connection allowing parents to receive real-time data on heart rate, movement, and emotional state.<sup>50</sup> Researchers are also developing wireless transceivers that can be placed around a bed to help monitor breathing rates of surgery patients, adults with sleep apnea, and babies.<sup>51</sup>

This sector is poised to explode. The installed base of connected devices within the health care sector is projected to exceed 774 million by 2020. And with all of this growth, total traffic generated by M2M applications in the healthcare sector is projected to grow at an astonishing 75% per year, from 283 terabytes in 2010 to nearly 78 petabytes by 2020.<sup>52</sup> While improving American’s health, this explosive

data growth also puts additional pressure on the growing spectrum crunch, and points to a prognosis of clogged arteries in our wireless circulatory system.

### III. Enabled by Accelerating Technological Advances

There is no doubt that the convergence of the Internet revolution with the mobile revolution has already produced astounding innovation. It has taken pragmatic policy choices, massive investments in R&D, and an army of innovators to propel us forward. We've gotten here through curiosity and creativity; talent and tenacity; ingenuity and innovation. These innovators have helped put smartphones on the map – literally. They put the capabilities once contained in tape players, paper maps, pay phones, VCRs, musical instruments, paperbacks, and video games and a host of other technologies into the palms of our hands. Each breakthrough created new jobs, new industries, and kept America the world's innovation leader. Now these innovators are creating another wave of opportunity – perhaps even more profound – driven by a number of key technological advances:

- ***Moore's Law is making faster, smaller, smarter, and more capable devices possible every 18 months.*** Forty years ago, Intel's first microprocessor had 2,300 transistors; today's microprocessors have over 2 billion transistors. As the intelligence has gone up, the costs have come down. It means that intelligence and connectivity can now be embedded into almost everything around us.
- ***Higher resolution sensors can enable us to connect to our world in ways beyond just our six senses.*** Sensors are the vital link between the physical world and the digital world. Our extra-sensory smart phones have become everything but phones, in part because they have been infused with sensors that can see and hear as well as sense touch, location, proximity, and movement. As devices advance and more sensors are developed, their usefulness will continue to increase exponentially – increasing the possibilities of what they are capable of doing and their value. Soon new devices might be fitted with sensors for moisture, elevation, temperature, infra-red vision and ultra-sonic hearing. Biosensors are being developed that can detect glucose levels in your blood, pesticides in a river, scents in the air, pathogens in your food, explosives at a crime scene, and even the molecules from a human breath to locate and save trapped survivors during disasters.<sup>53</sup> Digitally connected sensors can enable people and machines to monitor a range of activities in remote or hard to reach areas that were previously if not impossible to monitor. They can enable people and automated systems to make decisions far more quickly, with greater precision, and bigger impact. And as with all technology driven by Moore's law, sensor resolution will continue to see dramatic improvements over time – in the same way that smart phones went from grainy photos to 6 to 8 megapixel cameras in just a few years. And with each increase in resolution comes a commensurate increase in capability – which also means an increasing need to transmit larger and larger amounts of data.
- ***Thin film technologies could soon turn almost any surface into a connected touchscreen display, and enable affordable intelligence to be implanted into almost anything.***<sup>54</sup> Because this technology is so thin (100 microns thick), computer circuits can be printed that are 98% translucent,

and therefore can be incorporated into glass, plastics, and affordably added to a variety of unimaginable gadgets and gizmos. It means that soon your bathroom mirror, kitchen counter, car's windshield, or your reading glasses can become smart connected digital displays – like those made famous in the movie “Minority Report.” It can enable entire new forms of “augmented reality” technologies that we can scarcely imagine today. And with advances in a Nobel prize winning technology called graphene (made of a single layer of carbon atoms), scientists are developing and demonstrating displays in their labs that are transparent, bendable, and stretchable – eventually enabling connected devices to be embedded into plastics, clothing, and things we can't even imagine today.<sup>55</sup> These and other flexible technologies are enabling innovators, doctors, and hospitals to explore “connected clothing” as an opportunity to improve healthcare, fitness, and safety.<sup>56</sup> And other forms of “thin film” printed circuits that can be manufactured using a process that resembles a printer are expected to reach the market soon – further reducing the cost of low-power computing sensors to pennies per unit. These technologies will enable connected sensors to be implanted into everything from toys, games, tickets, promotional items, and proximity sensors.<sup>57</sup> The cheaper these chips are, the more places they can be put, and the more connected we are.

- ***Near Field Communication (NFC) technologies can enable new forms of mobile commerce.*** Near-field communication (NFC) technologies promise to transform our wallets and the way we pay for things by enabling us to wave our phones across a register, kiosk or vending machine to pay for items. To make them widely available, smartphone manufacturers have to build them into phones, credit card companies need to handle the transactions, and retailers must install an array of new connected devices in vending machines and retail outlets to accept the NFC enabled payments. Analysts project that this short-range communication technology is about to unleash a mobile payment revolution in the U.S. Although it is the future for the U.S., it is already technological reality for parts of Asia, particularly Japan.
- ***Radio Frequency Identification tags can help unleash ambient intelligence networks.*** A near invisible network of radio frequency identification tags (RFID) is being deployed in almost every type of consumer item. These tiny, traceable chips are being produced by the billions, and are capable of being wirelessly scanned, identified, and connected to the Internet in an instant. This so-called ‘ambient intelligence’ promises to create a global network of physical objects every bit as pervasive and ubiquitous as the worldwide web itself.
- ***Better human computer interaction can unlock new applications.*** We may never need to interact directly with many types of connected devices. However, new technologies can open up vast new opportunities. Some devices can be controlled through simple SMS commands or by logging into a web server. But more complex applications are enabled with voice or gesture recognition technologies that improve the way we work, learn, and play. For people with disabilities, they can also improve their ability to participate in the workplace and interact with the world around them. Already, innovators like Omek Technologies are developing tools to enable these gesture and body tracking technologies so they can be easily incorporated into new devices.<sup>58</sup> Likewise, in MIT's Sixth Sense labs, researchers are developing new gestural interfaces for mobile devices that augment the physical world around us.<sup>59</sup> Innovators are also working to develop connected devices that can

recognize objects with 3D vision, using technologies like those in Microsoft's Kinect, to create context sensitive applications capable of recognizing real-world objects and acting upon that information.<sup>60</sup>

- ***DIY connected device applications can enable innovation as dynamic as today's apps economy.*** One of the greatest developments coming out of the smartphone revolution is the "Apps Economy." It has unlocked a new frontier in innovation by enabling virtually any software developer with a good idea and an Internet connection to compete to become the next killer-app and online millionaire. Now there are nearly 1,000,000 mobile applications available, and apps sales are projected to approach \$38 billion by 2015. In the connected device world, this innovation ecosystem can be multiplied as connected sensors, servos, switches, actuators, valves, motors, and appliances enable previously unimaginable new applications. One of the more exciting, and potentially transformative developments has been the development of do-it-yourself connected device hardware kits that enable developers to innovate further by giving creative innovators the ability to plug a variety of different types of hardware modules, sensors, and actuators together to invent new applications never before created.<sup>61</sup> Telit, for example, makes devices that connect to cellular networks and physically connect with the popular Arduino set of DIY devices that are bringing intelligence to everything from robots to coffeemakers. And there are Internet interface programming platforms like ThingSpeak that are specifically designed for enabling backyard innovators to build and program their own connected devices. They enable the kind of backyard innovations that have always been essential for pushing the boundless frontiers of the possible.
- ***Vast video networks can improve safety, security, and the environment.*** When live monitoring is needed, live video feeds are often being deployed over commercial cellular networks for remote security cameras, nanny-cams, public transportation cameras, ambulance feeds, police car monitoring, and environmental sensors. A half hour of this video can generate 3.6 GB of data. Cisco estimates that if half the 10,000 buses, trucks, and emergency vehicles equipped with security cameras for the Shanghai World Expo transmitted just 1 hour of video over the course of a month, this would generate 18 petabytes of mobile data traffic, more than the total global mobile data traffic in 2007. Video traffic already accounts for more than 50% of total mobile data traffic, will more than double every year between 2010 and 2015, and will constitute two-thirds of mobile data traffic by 2015.<sup>62</sup> As video recognition tools advance and their use becomes even more valuable, video use will continue to explode as a remote monitoring technology – putting further pressure on the looming spectrum crunch.
- ***Expanding investment in and ubiquity of next generation wireless networks.*** The President's strategy for expanding next generation wireless coverage to 98 percent of all Americans within five years will be essential for ensuring that the benefits of connected devices extend to all corners of the country.<sup>63</sup> The flexibility and speed enabled through next generation 4G wireless networks are critical for supporting the broad range of connected applications and devices and reaping their benefits. The ubiquity of networks will also be an important enabler for mobile applications (like health monitors) that depend upon being able to reach the networks wherever the user may be. It

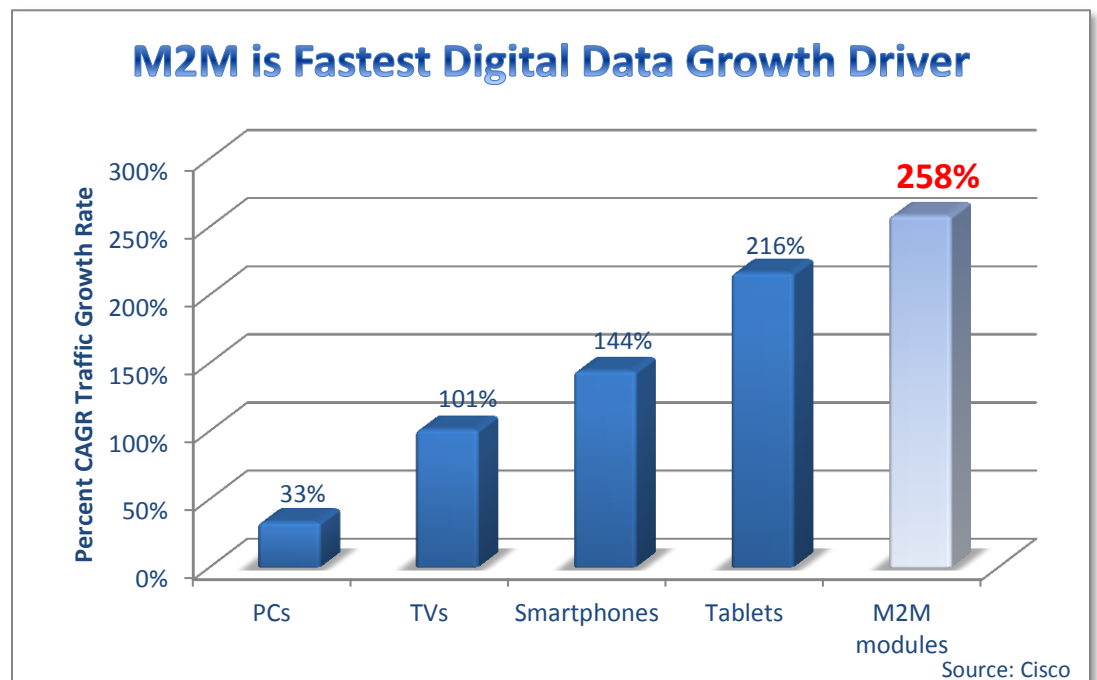
will require robust investment, and the policies that enable it, to advance networks that go farther and run faster.

These technology enablers are essential for unlocking the vast new opportunities that can come from the dizzying array of digital devices now emerging from labs across the country. When combined with the same kind of advances that made smart phones possible – advances that can help us sense the world around us and interact with it – connected devices promise to transform our world in unprecedented ways.

#### IV. Explosive M2M Growth Could Further Exacerbate The Spectrum Crunch

***This coming digital device deluge will further accelerate mobile opportunity and exacerbate the looming spectrum crunch.*** Smartphones, tablets and an ever-expanding array of mobile gadgetry have become nearly ubiquitous, and modern life is being transformed by the power of the Internet in the palms of our hands.

This new wave of devices with the ability to scale to billions of units in a wide range of different industries will further propel mobile data growth. And as sensor resolution improves, Moore’s law advances, the sophistication of applications evolves, and connectivity is increasingly embedded in virtually every type of machine and device, the flow of bits will continue to grow exponentially.



The number of connected devices is poised to explode, as will the amount of bandwidth each uses. By one estimate, there will be 50 billion connected devices by 2020 – 10 times the number of people connected to mobile networks today.<sup>64</sup> The growing number of connected devices combined with the increasing capability each application enables is converging to make these the fastest growing digital



data drivers. Between now and 2015, M2M data will grow at an astounding rate of 258% per year – faster than tablets, smartphones or PCs.<sup>65</sup>

As mobile data networks become more ubiquitous, bandwidth-intensive M2M applications become more prevalent. While first generation M2M devices like home appliances, ATMs, energy meters, and vending machines may not have initially been connected directly to cellular networks, more devices are now turning to wireless networks for mobility and data connectivity.

As a result, these connected devices will boost wireless data usage 40 times between 2010 and 2015.<sup>66</sup> They are bringing about near exponential opportunity, but doing so with near exponential data growth.

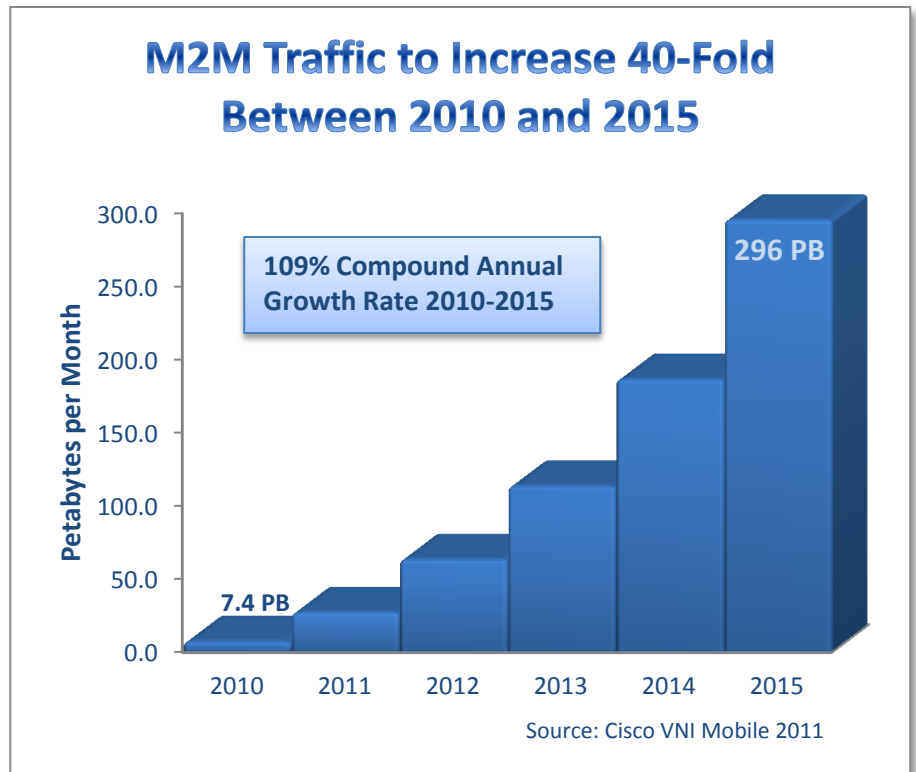
***But lack of available spectrum could stall, stifle, or even stop these benefits from coming to fruition.***

Much of these amazing M2M device enabled benefits are made possible by spectrum – the invisible infrastructure that connects us wherever we are, whenever we want. Wireless spectrum is to the 21st century, what oil and electricity were to the industrial age: a fundamental fuel driving our economic engine.

But with smartphones gobbling up available spectrum at incredible rates and this new transformation sharply increasing the number of wireless connections, we face a spectrum crunch that could inhibit the essential fuel necessary for driving this next wave of the mobile revolution.

Without proactive policy changes that allocate more spectrum for wireless services, our nation's appetite for wireless capability could outstrip capacity as soon as 2014 – reducing opportunities for millions of consumers and businesses, and jeopardizing U.S. technological leadership.<sup>67</sup> This spectrum crunch is the single

biggest threat to one of the very most promising parts of our economy. But unlocking more spectrum can help extend the limits of the Internet, stretch the bounds of current applications, and push back the confines of innovation.



## V. Pragmatic Policy Prescriptions for Advancing the Digital Device Decade

This newfound digital opportunity won't happen by accident, nor continue by inertia. It will only happen if we make pragmatic policy choices about our communications future. First, it requires critical policy steps to keep the innovation pipeline running including making available more spectrum; increasing investments in targeted research to stoke the innovation bonfire again; advancing enlightened Internet policy; enabling capital formation and investment; protecting privacy and security; and ensuring that we are training the next generation of scientists, engineers and developers who are necessary for inventing the next new thing.

### Five Common Sense Steps For Advancing Connected Device Innovation:

1. **Unleash Additional Mobile Spectrum Now.** Policymakers should act immediately to free up more spectrum for mobile and advance this connected device revolution. With exponentially increasing spectrum demand, the most important policy enabler for achieving the vast benefits from this connected device revolution is making more spectrum available. To address this challenge, the President, the FCC, and leaders in Congress have proposed making 500 MHz available for mobile broadband use over the next ten years. The plan would create up to 500,000 U.S. jobs and add some \$400 billion to the nation's GDP.<sup>68</sup> If we don't allocate more spectrum for mobile connectivity, our nation's appetite for wireless will out-strip capacity as early as 2014, and the vast opportunity for M2M will be delayed.
2. **Stoke the Innovation Bonfire.** We need continued investments in the basic building blocks that enable innovation – in the science, research and technology that leads to new discoveries, new features, and the continuously accelerating advances that fuel the mobile future. Federal investments in basic research have been instrumental to the advancement of many of the fundamental technologies at the core of today's smartphones –the Internet connection, lithium-ion batteries, the hard drive, the memory chips, the liquid crystal display, and even Siri – have their roots in basic federally-funded research.<sup>69</sup> Going forward, policymakers can continue to feed this innovation pipeline by following through on Congressional and Administration commitments to double basic research at key science agencies.<sup>70</sup> This enables ongoing critical research into spectrum efficiency, networking, sensors, cyber-physical systems, thin-film fabrication, and computing that are necessary for accelerating the benefits from connected devices and ensuring U.S. leadership in this next phase of the Internet's evolution.<sup>71</sup>
3. **Protect Privacy and Promote Security to Enable a Trusted Device Revolution.** Innovators and entrepreneurs need to think ahead about the provocative security implications of devices that can connect to and sometimes help control things in the physical world, and the privacy implications of devices that can harvest terabytes of new information about us and the world around us.<sup>72</sup> With so many devices that may not have or may not need the computing power to run modern anti-virus and other cybersecurity protections at the edge of the network, we may

need to explore how network providers can play a more central role in providing smart cybersecurity solutions for less intelligent connected devices.

4. ***Advance Smart Internet Policy Principles for Enabling a Connected World.*** Significant investment is still needed to deploy the mobile networks that connect these devices and to develop the apps that will bring them to life. Attracting this investment requires us to sustain the pro-innovation, pro-growth policies that have made American wireless innovation not just an engine for economic growth, but one of the most powerful drivers of new opportunities. It requires policymakers to continue to adopt smart policies that remove barriers to innovation and help ensure that anyone with a good idea and an Internet connection can help connect the physical world to the global economy. A growing number of connected devices rely upon Internet cloud technologies to access and store data. To ensure that the U.S. can lead, and sell devices applications and services globally, policymakers need to advance global Internet principles that prevent the balkanization of the cloud.<sup>73</sup> It means taking the light-handed Internet policy model that has worked so well in the U.S. – a model that is elegant in its restraint—and help advance that model around the globe so that in a world once limited by borders on a map, the only limits we face in this broadband enabled world are the limits of our own imaginations.
5. ***Ensure a Talented Workforce and the Next Generation of Gee Whiz Device Developers.*** Getting to this point has taken pragmatic policy choices and a nation of innovators who have sweated long nights pushing their limits and pursuing their dreams. To continue this dynamism we need to invest in our human capacity – into the next generation of scientists and engineers that are necessary for developing the next connected device or mobile app. Unfortunately, the United States is facing a crisis in Science Technology Engineering and Mathematics (STEM) training and workforce development.<sup>74</sup> As a result, many Silicon Valley CEOs say they have plenty of openings, they just can't find people with the right skills to fill the jobs.<sup>75</sup> We need to turn out an additional 10,000 American engineers annually as recommended by the President's Jobs and Competitiveness Council. It means we need to recruit, prepare, retain, and support 100,000 excellent STEM teachers over the coming 10 years. There are important public and private sector efforts aimed at advancing these goals.<sup>76</sup>

#### **Five Key Steps For Harnessing Connected Devices For Broader Societal Gains:**

In addition to these five core policy steps for enabling robust connected device innovation, there are additional key targeted steps policymakers should take to harness this connected device revolution for achieving broader national goals including smarter ways to grow our economy, protect our environment, improve public safety, and raise our standards of living. It requires smarter policies for enabling the smart grid, advancing smart cities, accelerating smart transportation, building smart infrastructure, delivering smarter health care, constructing better buildings, and infusing connected intelligence into the manufacturing process for a brighter connected future.

1. **Catalyze Innovation Through a Wireless Innovation Fund (WIN):** To spur innovation, the President has proposed using \$3 billion of spectrum auction proceeds to create a Wireless Innovation (WIN) Fund to invest in critical research and development that supports emerging wireless technologies and applications.<sup>77</sup> The WIN Fund will take advantage of on-going 4G rollouts and support critical basic research, experimentation and testbeds, and applied development in a number of areas, including public safety, education, energy, health, transportation, and economic development.
2. **Accelerate Smart Infrastructure Development and Deployment.** Government investment in new infrastructure to create new jobs should not only focus on traditional infrastructure like roadways, railways, and runways, but should also invest in smart infrastructure that infuses intelligence throughout to improve efficiency, safety, and maintenance. It means new investments to advance smart bridges that continuously monitor safety and transmit problems in advance.<sup>78</sup> It means investing in smarter cities that connect core city systems including subways, sewers, and streets to increase the flow of traffic, create safer neighborhoods, reduce costs, and improve quality of life. It also means improving the environment for cell siting processes, enabling the robust and dense networks necessary to support the growth in deployed connected devices.
3. **Advance a Smarter Electric Grid to Boost Efficiency And Cut Energy Costs.** The President has proposed using \$100 million from the Wireless Innovation Fund for wireless-related SmartGrid technologies and more. We need to advance the SmartGrid, and the ability to control our energy usage remotely from our mobile devices.
4. **Speed Up The Medical Device Approval Processes For Wireless Connected Technologies.** We need to get innovative wireless medical devices to consumers as quickly and safely as possible. These connected devices have the potential to save money, save time, and save lives. It takes advancing a “moon shot” goal for the development of transformative new devices.<sup>79</sup> But when wireless and medical devices converge, the regulatory lines between the FCC (who approves wireless devices) and the FDA (who approves medical devices) becomes blurred. Numerous studies have found that medical device approval times are taking longer, and regularly take 2 years longer than our European counterparts – impinging on U.S. competitiveness.<sup>80</sup> Agencies need to clarify the lines, and seek to accelerate a safe FDA medical device approval process for devices integrated with wireless networks.
5. **Ensure That More Of These Connected Devices Are Made In America by Supporting American Leadership In Advanced Manufacturing.** Unfortunately, the United States no longer leads the world in our ability to produce the LED’s, lithium-ion batteries, advanced displays, and other critical components for today’s wireless connected devices like Kindle’s and smartphones.<sup>81</sup> Companies in Asia now make nearly every U.S. brand of mobile device and laptop computer.<sup>82</sup> But through new efforts like the Advanced Manufacturing Partnership, designed to create a renaissance in American manufacturing and help U.S. manufacturers develop the cutting-edge tools they need to compete with anyone in the world, we can establish U.S. leadership in next-generation robotics, develop manufacturing leadership in building the sensor and other

technologies vital for this revolution, and develop new technologies that will dramatically reduce the time required to design, build, and test connected devices.

## VI. Conclusion

In this digital device transformation, some will win, but others will win bigger. The important dividing line is not between those who deploy digital devices, and those who don't, or even between the early adopters and the laggards. The dividing line is likely to be between those who see connected devices as just a new way to do the same old things and those who use it to rethink their entire business strategy.

America deserves a mobile future that is defined by perpetual innovation, progress and growth. Our nation has an extraordinary appetite for wireless products, data, and services across a dizzying array of applications and devices. The massive growth of wireless connected devices, including the explosive smartphone adoption, means we will quickly exceed the available wireless spectrum. If we don't allocate more spectrum for mobile connectivity, our nation's appetite for wireless will out-strip capacity as early as 2014, and the vast opportunity for M2M will be delayed. To address this challenge, the President, the FCC, and leaders in Congress have proposed making 500 MHz available for mobile broadband use over the next ten years. The plan would create up to 500,000 U.S. jobs and add some \$400 billion to the nation's GDP. Policymakers must act immediately to free up more spectrum and advance this connected device revolution.<sup>83</sup> Nowhere is the opportunity so vast, the need so urgent, and the policy so vital for advancing a brighter mobile future.

### Endnotes:

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<sup>1</sup> Ericsson CEO and President, Hans Vestberg, predicted that by the year 2020 there will be 50 billion connected devices to the web.<http://www.thehindubusinessline.com/features/eworld/article2038202.ece?homepage=true> GSMA reports the number of total connected devices is expected to increase from approximately 9 billion today to more than 24 billion in 2020, and within that, mobile connected devices(2) will grow 100 per cent from more than 6 billion today to 12 billion in 2020.<http://www.prnewswire.com/news-releases/gsm-a-announces-that-the-proliferation-of-connected-devices-will-create-a-us12-trillion-revenue-opportunity-for-mobile-operators-by-2020-131484733.html>

<sup>2</sup> <http://www.gsm.org/newsroom/press-releases/2011/6491.htm>

<sup>3</sup> The U.S. Wireless Industry-An Overview, CTIA, 8/30/2011

<sup>4</sup> "Use of technology can cut CO2 emissions by 25%: IDC." The study looked at infusing technology into various sectors including Energy Generation and Distribution; Transportation; Industry; and Buildings.

<http://www.asiaone.com/Business/SME%2BCentral/Tete-A-Tech/Story/A1Story20091211-185329.html>

<sup>5</sup> "Delivering Next Generation Citizen Services" by market researcher IDC, found that crime could be reduced by as much as 20% by creating smart connected cities that are infused with technology.

[http://www.cisco.com/web/strategy/docs/scc/whitepaper\\_cisco\\_scc\\_idc.pdf](http://www.cisco.com/web/strategy/docs/scc/whitepaper_cisco_scc_idc.pdf). A growing body of evidence also suggests that connected monitoring cameras can reduce crime in communities, while parcels packages, inventory systems and cars are being connected with devices (like LoJack) that enable the owner to know when they are being inappropriately moved, and track them down when stolen.

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<sup>6</sup> Connected traffic lights, next generation navigation systems, connected road sensors, apps to track buses and subway transit systems, and connected fleet management systems can cut traffic delays. IDC estimates that a digitally infused smart city could cut traffic by as much as 20%.

<sup>7</sup> "Intelligent Traffic Solutions," Siemens AG <http://www.siemens.com/sustainability/en/environmental-portfolio/products-solutions/mobility/intelligent-traffic-management.htm>

<sup>8</sup> From driver monitoring systems that give truck drivers feedback on their driving to vehicle to vehicle communication systems, and traffic avoidance systems – connected devices can help reduce accidents. By one estimate, by letting a car know what is happening ahead of them, accidents could be reduced by as much as 40%. <http://www.bbc.co.uk/news/technology-14125245>

<sup>9</sup> The National Highway Traffic Safety Administration (NHTSA) estimates that collision notification systems could reduce fatalities by as much as 20%. Institute of medicine, "Future of Emergency Care" report

<sup>10</sup> The proliferation of connected devices is projected to create \$1.2 trillion in economic activity by 2020. <http://www.gsm.org/newsroom/press-releases/2011/6491.htm>

<sup>11</sup> <http://www.dailymail.co.uk/news/article-1353527/Americans-waste-70-hours-808-year-sitting-traffic-jams.html>

<sup>12</sup> <http://www.investors.com/NewsAndAnalysis/Article.aspx?id=577320&p=1>

<sup>13</sup> The Next Boom in Mobile Devices Is the Car, New York Times 10-23-11, <http://bits.blogs.nytimes.com/2011/10/13/the-next-boom-in-mobile-devices-is-the-car/>

<sup>14</sup> <http://www.connectedworldmag.com/latestNews.aspx?id=NEWS111103094848630>

<sup>15</sup> Integration of ACN systems and other telematics with the existing Public Safety Answering Point (PSAP) infrastructure (the 9-1-1 system) is a critical issue. [http://www.its.dot.gov/pubsafety/law\\_itsnotification.htm](http://www.its.dot.gov/pubsafety/law_itsnotification.htm)

<sup>16</sup> Institute of medicine, "Future of Emergency Care" report

<sup>17</sup> Road tests of the software will be carried out in August 2011 on the streets and freeways of Los Angeles in conjunction with car maker Toyota. <http://www.bbc.co.uk/news/technology-14125245>

<sup>18</sup> <https://www.bump.com/>

<sup>19</sup> <http://parknow.us/>

<sup>20</sup> <http://www.tmcnet.com/voip/features/articles/206346-thats-logistics-m2m-solutions-support-asset-tracking-real.htm>

<sup>21</sup> <http://www.senseaware.com/>

<sup>22</sup> [http://www.berginsight.com/News.aspx?m\\_m=6&s\\_m=1](http://www.berginsight.com/News.aspx?m_m=6&s_m=1)

<sup>23</sup> <http://www.m2mnow.biz/2011/08/24/2330-greenroad-wins-techies-award-for-fleet-product/>

<sup>24</sup> Analysys Mason 2011 projects the utility sector will utilize 1.32 billion connected devices or 62% of the market.

<sup>25</sup> "Intelligent Traffic Solutions," Siemens AG <http://www.siemens.com/sustainability/en/environmental-portfolio/products-solutions/mobility/intelligent-traffic-management.htm>

<sup>26</sup> American Lighting Association

<sup>27</sup> <http://www.connectedworldmag.com/latestNews.aspx?id=NEWS110606122100210>

<sup>28</sup> <http://www.neoninc.org/>

<sup>29</sup> The iPad takes on Manufacturing. <http://www.cio.com/article/print/688714>

<sup>30</sup> <http://www.fastcompany.com/1774491/your-next-home-is-a-robot>

<sup>31</sup> According to ABI Research <http://www.fastcompany.com/1774491/your-next-home-is-a-robot>

<sup>32</sup> Analysys Mason, 2011

<sup>33</sup> <http://www.cetlylive.com/spybot-a-3g-control-based-robot/>

<sup>34</sup> <http://www.networkworld.com/community/node/73618>

<sup>35</sup> <http://www.engadget.com/2011/02/03/texas-student-sends-robot-to-school-in-his-place-cant-get-it-t/>

<sup>36</sup> [http://today.msnbc.msn.com/id/43521646/ns/today-today\\_news/t/challenges-red-light-cameras-span-us/](http://today.msnbc.msn.com/id/43521646/ns/today-today_news/t/challenges-red-light-cameras-span-us/)

<sup>37</sup> The most recent, published in February by the Insurance Institute for Highway Safety, crunched 10 years of federal traffic data for the 99 largest U.S. cities — 14 of which now deploy cameras — and calculated that had all 99 installed the devices, 815 lives would have been saved from 2004 through 2008.

<sup>38</sup> <http://www.policemag.com/Channel/Technology/Articles/Print/Story/2009/12/Unblinking-Eyes.aspx>

<sup>39</sup> according to a four-year study of the technology in Baltimore and two other major cities by the Urban Institute's Justice Policy Center. [http://articles.baltimoresun.com/2011-09-19/news/bs-md-ci-crime-camera-study-20110919\\_1\\_crime-cameras-dashboard-cameras-surveillance-cameras](http://articles.baltimoresun.com/2011-09-19/news/bs-md-ci-crime-camera-study-20110919_1_crime-cameras-dashboard-cameras-surveillance-cameras)

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- <sup>40</sup> <http://www.foxnews.com/leisure/2009/11/13/smart-traffic-lights-double-fuel-efficiency/>
- <sup>41</sup> [http://www.cisco.com/web/strategy/docs/scc/whitepaper\\_cisco\\_scc\\_idc.pdf](http://www.cisco.com/web/strategy/docs/scc/whitepaper_cisco_scc_idc.pdf)
- <sup>42</sup> <http://www.dailywireless.org/2011/01/04/bottle-caps-talk-machine-to-machine/>
- <sup>43</sup> Each year, there are about 127,000 critical wandering cases. A variety of technologies exist including GTX Corp's GPS shoes, and EmFinders secure band which uses the cellular network to locate a person in the event of an emergency. Other technologies include LifeTracker, and GPS Pendant Plus. <http://nycseniorcare.org/gps-digital-tracking-devices-for-dementia-and-alzheimers-patients/> <http://www.tomsguide.com/us/GPS-Shoes-Alzheimers-Dementia-Tracking,news-13141.html> <http://www.emfinders.com/>
- <sup>44</sup> <http://www.trendhunter.com/trends/hi-tech-band-aid-the-sensium> <http://www.technovelgy.com/ct/Science-Fiction-News.asp?NewsNum=1448>
- <sup>45</sup> According to an IBM survey that tracks trends in the use of mobile devices in healthcare. <http://www.informationweek.com/news/healthcare/patient/231000506>
- <sup>46</sup> <http://www.kaloramainformation.com/Remote-Wireless-Patient-6487095/>
- <sup>47</sup> <http://www.m2minsights.com/index.php/health-a-medical/297-upmc-and-alcatel-lucent-team-to-develop-next-generation-telemedicine-solution>
- <sup>48</sup> Frank Moss, an entrepreneur and former director of the M.I.T. Media Lab has called for a "moon shot" type goal for a "digital nervous system" of wireless connected devices that can monitor, prevent, and improve our health. See New York Times op-ed, by Frank Moss, November 10, 2011, [http://www.nytimes.com/2011/11/10/opinion/our-high-tech-health-care-future.html?\\_r=1&nl=todaysheadlines&emc=th212](http://www.nytimes.com/2011/11/10/opinion/our-high-tech-health-care-future.html?_r=1&nl=todaysheadlines&emc=th212).
- <sup>49</sup> X-Prize Tricorder competition: [http://www.youtube.com/watch?feature=player\\_embedded&v=4OT3bDiMWK0](http://www.youtube.com/watch?feature=player_embedded&v=4OT3bDiMWK0) <http://www.marketwire.com/press-release/x-prize-foundation-qualcomm-join-forces-develop-competition-enhance-integrated-digital-1512263.htm>
- <sup>50</sup> Exmovere Holdings, [www.exmovere.com](http://www.exmovere.com), a biomedical engineering company based in McLean, Va. <http://www.connectedworldmag.com/latestNews.aspx?id=NEWS100915073821177>
- <sup>51</sup> "Wireless Network Can Monitor Breathing Rates" By Nicole Lewis <http://www.informationweek.com/news/healthcare/mobile-wireless/231601980>
- <sup>52</sup> Machina Research
- <sup>53</sup> <http://en.wikipedia.org/wiki/Biosensor>
- <sup>54</sup> Thin Film Turns Any Surface Into a Touchscreen, Wired Magazine, By Priya Ganapati, February 2, 2010 <http://www.wired.com/gadgetlab/2010/02/thin-film-touchscreen/>
- <sup>55</sup> MIT Technology Review, Bigger Stretchier Graphene: High-quality, clear grapheme films are a leap toward bendable OLED displays. January 15, 2009 <http://www.technologyreview.com/computing/21964/>
- <sup>56</sup> AT&T Pushes 'Connected' Clothing For Healthcare, Telecom giant sees growing market in eldercare, fitness, and childcare for wireless sensors embedded in clothing to monitor vital signs. Information Week, November 4, 2011 <http://informationweek.com/news/healthcare/mobile-wireless/231902320>
- <sup>57</sup> <http://gigaom.com/2011/10/20/new-printed-chip-could-spark-cheaper-sensor-networks/>
- <sup>58</sup> <http://www.omekinteractive.com/>
- <sup>59</sup> <http://www.pranavmistry.com/projects/sixthsense/>
- <sup>60</sup> <http://en.wikipedia.org/wiki/Kinect>
- <sup>61</sup> For example, Telit, ioBridge, openPicus, Digi, and other sell I/O hardware modules that connect a variety of devices, sensors and servos to the Internet for easy monitoring and control using any web-based browser. <http://iobridge.com/div/> <http://www.digi.com/>
- <sup>62</sup> The Cisco® Visual Networking Index (VNI) Global Mobile Data Traffic Forecast, [http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white\\_paper\\_c11-520862.html](http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html)
- <sup>63</sup> President Obama Details Plan to Win the Future through Expanded Wireless Access, February 10, 2011 <http://www.whitehouse.gov/the-press-office/2011/02/10/president-obama-details-plan-win-future-through-expanded-wireless-access>
- <sup>64</sup> Ericsson <http://www.thehindubusinessline.com/features/eworld/article2038202.ece?homepage=true>

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<sup>65</sup> Cisco® Visual Networking Index (VNI) Global Mobile Data Traffic Forecast, [http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white\\_paper\\_c11-520862.html](http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html)

<sup>66</sup> [http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white\\_paper\\_c11-520862.html](http://www.cisco.com/en/US/solutions/collateral/ns341/ns525/ns537/ns705/ns827/white_paper_c11-520862.html)

<sup>67</sup> Without additional spectrum capacity, which all mobile infrastructure relies upon to make wireless connectivity possible, analysis by engineer Peter Rysavy finds that demand for U.S. wireless networks will outstrip existing capacity in as little as four years' time.

<sup>68</sup> Mobile Future Spectrum Impact Study. <http://www.mobilefuture.org/page/-/spectrum-impact-study.pdf>

<sup>69</sup> The iPhone 4S Siri technology is a direct outgrowth of a federally-funded research project called the "Personalized Assistant that Learns" at the Defense Advanced Research Projects Agency (DARPA), according to the White House. <http://www.whitehouse.gov/blog/2011/10/17/applying-iphone-innovation-better-schools-and-cleaner-energy>

<sup>70</sup> Congress passed the America Competes Act to double investments in key science agencies over the next 10 years. <http://www.nature.com/news/2010/101222/full/news.2010.693.html> Similarly, the White House prioritized and proposed budgets to double investments in key science agencies even while holding overall budgets flat. <http://www.whitehouse.gov/sites/default/files/microsites/ostp/FY12-doubling-fs.pdf>

<sup>71</sup> Examples of critical ongoing research efforts include: NSF's Enhancing Access to the Radio Spectrum (EARS) program which seeks to find innovate new approaches to alleviating our spectrum crunch [http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=503480](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503480); NSF's Science and Engineering Beyond Moore's Law (SEBML) program designed to unlock ways to enable even more transformative connected computing devices and ensure that advances in computing power continue for decades to come [http://www.nsf.gov/about/budget/fy2012/pdf/41\\_fy2012.pdf](http://www.nsf.gov/about/budget/fy2012/pdf/41_fy2012.pdf); NSF's Cyber-Physical Systems (CPS) program which seeks to advance broad societal goals through research into devices, sensors, actuators, and systems that connect the Internet to our physical world. According to NSF, "Research advances in cyber-physical systems promise to transform our world with systems that respond more quickly (e.g., autonomous collision avoidance), are more precise (e.g., robotic surgery and nano-tolerance manufacturing), work in dangerous or inaccessible environments (e.g., autonomous systems for search and rescue, firefighting, and exploration), provide large-scale, distributed coordination (e.g., automated traffic control), are highly efficient (e.g., zero-net energy buildings), augment human capabilities, and enhance societal wellbeing (e.g., assistive technologies and ubiquitous healthcare monitoring and delivery)." [http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=503286&org=CISE](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503286&org=CISE); and NSF's Smart Health and Wellbeing (SHB) effort focused on research to harness sensor and networking devices to radically improve our personal health and well-being.

[http://www.nsf.gov/funding/pgm\\_summ.jsp?pims\\_id=13451&org=CISE&from=home](http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=13451&org=CISE&from=home)

<sup>72</sup> Mobile vendors appear to be taking security seriously. Research firm IDC says global spending on mobile security is on track to balloon to \$1.9 billion by 2015, up from \$407 million in 2010.

<sup>73</sup> Agreement Reached on Internet Policymaking Principles, <http://www.whitehouse.gov/blog/2011/07/01/agreement-reached-internet-policymaking-principles>

<sup>74</sup> According to the Program for International Student Assessment scores, American 15-year-olds ranked 21st in science and 25th in math compared to other countries.

<sup>75</sup> [http://www.msnbc.msn.com/id/43465034/#.TsE\\_2sMk6nA](http://www.msnbc.msn.com/id/43465034/#.TsE_2sMk6nA)

<sup>76</sup> In the 2011 State of the Union Address, the President put out a call to action: To train 100,000 new, excellent STEM teachers over the next 10 years to keep America vibrant and prosperous. The President's 2012 budget proposes \$100 million toward that goal. <http://www.whitehouse.gov/sites/default/files/microsites/ostp/OSTP-fy12-STEM-fs.pdf> Likewise, 100Kin10 is a collaborative movement created in response to our nation's need for 100,000 new, excellent science, technology, engineering, and math (STEM) teachers in 10 years.

<http://100kin10.org/> .

<sup>77</sup> <http://www.whitehouse.gov/sites/default/files/microsites/ostp/Wi3-fs.pdf>

<sup>78</sup> <http://buildipedia.com/operations/public-infrastructure/innovative-infrastructure-smart-bridges>

<sup>79</sup> Frank Moss, an entrepreneur and former director of the M.I.T. Media Lab has called for a "moon shot" type goal for a "digital nervous system" of wireless connected devices that can monitor, prevent, and improve our health. See New York Times op-ed, by Frank Moss, November 10, 2011,

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[http://www.nytimes.com/2011/11/10/opinion/our-high-tech-health-care-future.html?\\_r=1&nl=todaysheadlines&emc=tha212](http://www.nytimes.com/2011/11/10/opinion/our-high-tech-health-care-future.html?_r=1&nl=todaysheadlines&emc=tha212).

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<http://democrats.oversight.house.gov/images/stories/SUBCOS/602%20hcdccna%20medical%20device/Jack%20Larsen%20Testimony%20-%20House%20Gov%20Reform%20June%20202011-Final.pdf>

<sup>81</sup> Pisano, Gary P., and Willy C. Shih. "Restoring American Competitiveness." *Harvard Business Review* 87, nos. 7-8 (July - August 2009). p.3 We no longer have the capacity to manufacture light-emitting diodes for energy-efficient illumination, components for consumer electronic products like the Kindle e-reader, or advanced displays for computers, and handheld devices such as mobile phones.

<sup>82</sup> Ibid.

<sup>83</sup> Analysis Group Spectrum Impact Study. <http://www.mobilefuture.org/page/-/spectrum-impact-study.pdf>