# The Integration of Bluetooth and WiFi into the Toy Industry

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MAE 576 Mechatronics

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May 16, 2003

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## Introduction

The implementation of electronics in consumer goods has been increasing at a faster and faster rate since their introduction in the late 1970's and early 80's. The toy industry has not been immune. As of the year 2000, 60% of the toys made by Fisher-Price incorporated electronics of some sort and the that number has grown ever since (Walker). Increasing electronic connectivity, interoperability, and smart systems have been working their way into the consumer marketplace in recent years. As specific electronic technologies become more widely used, and prices for the chips and solutions drop, a greater range of applications opens up. Wireless communication, specifically bluetooth and WiFi are two technologies that are poised to soon be commercially viable in childrens products and toys. By looking at the way children interact with the toys available on the market now, future applications for these new technologies can be identified and possibly slated for future development.

**Toy-Child Interaction**

There are many ways in which children can interact with toys beyond the tradition touch oriented play. Electronics in toys range from simple button activation to Infrared and Radio Frequency technologies. Traditional remote control cars using RF have been around for many years, but now Infrared is being used to transmit control information to toys. Clicker technology and RF tagging have also been used to detect elements in near proximity and enhance the play pattern with "smart" reactions. Toys have also been coupled to the personal computer, incorporating either clamp on keyboard devices, or direct input. Many learning toys incorporate downloadable content which can be fed to a cartridge and used in handheld interactive toys.

To help examine that different modes of interaction, the interface between the child and the toy can be broken down into four major categories: touch activation, sound activation, remote sensing and instruction transmission, and finally content and data transmission.

Fisher-Price, one of the leading toy makers in the industry is often on the cutting edge of implementing new electronic toys on a mass market scale. "Cutting edge" in the toy industry usually applies to an existing technology becoming cheap enough for integration into a market with such a low price point. For this reason, many examples of the different types of interaction can be pulled from the Fisher-Price product lines over the years.

In 1996 Fisher-Price introduced a Tickle-Me-Elmo doll that became a smash hit. This doll, when squeezed, hugged, or tickled exhibited a reaction to the child's input. This type of toy exhibits the first category of child-toy interaction. To the child, it seems like the toy is alive, but from a mechanical and electrical standpoint, the toy consists only of a microcontroller that is interfaced to a switch on the dolls belly. When the switch is pressed, the mircrocontroller chooses phrases for the doll to output to the speaker, and activates a motor that makes the doll shake. A later version of the doll, Tickle-Me-Elmo Surprise incorporated multiple "tickle" points that further enhanced the play by providing

more points where Elmo could be “tickled.” This toy is a good example of simple touch activation based on buttons.

Voice activation is another way in which kids interact with their toys. Fisher-Price's Rocket the Wonder Dog, a lower tech, preschool version of the Sony Aibo dog, operated via voice command. The toy came with a headset accessory which included a microphone positioned in proximity to the child's mouth. When the child spoke specific commands, such as “sit” or “lay down”, the toy responded accordingly. Rocket the Wonder dog also exhibited simple command transmission through an IR interface between the headset and the dog. When the child spoke, the headset converted the verbal command into a binary signal which the processor on the robot then interpreted and sent the appropriate signals to the motors and sound chips.

With both clicker and tagging technology, the child's play with the toy is enhanced through the sensing of other accessories. The Fisher-Price Little People Airport is an example of a toy that operates using clicker technology. The toy consists of a base with an airport and runway, along with several accessory vehicles, including a helicopter. As the helicopter blades are spun, there is a cogged gear with teeth placed around the circumference in a specific pattern. When a piece of material interfaces with the cog to produce a click, the clicks occur in a specific bit pattern as laid out on the gear. The electronics in the base can recognize the specific bit pattern for that accessory and react with specific sounds and lights appropriate for the situation.

Tagging technology takes this process one step further. With tagging technology, such as that used in the Mattel He-man Greyskull Castle, a coil is located in the accessory which, when placed into an oscillating RF field, generates enough power to send back a signal to the main processor in the main toy. The data that is transmitted back to the processor uses PWM/ASK modulation with the transmission information stored in a 96 bits one time programmable memory (Holteck, 1). Unlike the clicker technology, tagging does not require any mechanical parts and also doesn’t need any batteries in the accessories.

The tagging technology allows the main IC to recognize different characters, and output sound effects and lights based on the particular accessory that is sending back the signal.

The fourth category of interaction of toys and their environment involves the transmission of data between the toy and some outside source. Currently, one of the leading makers of learning toys is Leapfrog. Leapfrog makes several toys that interface with web content via proprietary cartridges. An example of this is the iQuest HandHeld and the Mind Station connector. This learning toy quizzes children in various subjects and is sold as a studying tool. By connecting the Mind Station to the cusumers home PC, the parent can download additional questions to cartridges that can be then placed in many of the company's handheld toys. While the child is playing with the toy, not only is the information being read off of the cartridge, but also the cartridge records what the child is doing, such as keeping track of how many quiz questions the child has got right or wrong. The parent can then put the cartridge back the into the Mind Station which is attached to the computer, and with an internet connection, can then use the LeapFrog website to interpret and view how well their child did. This service is free for the first six months but then requires a monthly fee for the service to continue (LeapFrog Enterprises).

There are many other toys that incorporate different kinds of interaction, and "smart" technology, such as Lego MindStorm, and the Sony Aibo dog (which is not a toy in the traditional sense), but the above descriptions provide a good cross section of the technology that is available on the mainstream toy market.

With the large bandwidth provided by bluetooth and WiFi, both wireless technologies have the ability to revolutionize the way children interact with their toys and how the toys interact with the environment. Rather than small bit sized pulses that are currently transmitted through toys, voice, content, and environmental data will be able to flow to and from adequately equipped devices.

**The Basics of Bluetooth and WiFi**

Bluetooth is a wireless communication protocol, with the key features of low power consumption and low cost. The trade-off is reduced range and bandwidth. Bluetooth communication can typically transmit about 1 Megabit per second, not including headers and handshaking, to a distance of 10m. Bluetooth communicates on the 2.4 Ghz Industrial, Scientific and Medical (ISM) band which is unlicensed and common worldwide. Bluetooth incorporates spread spectrum frequency hopping that allows multiple devices to share the same set of frequencies. By changing frequencies after every packet is sent, more devices can use the same set of frequencies and they can avoid interference from other equipment using the same band.

Bluetooth is divided into many standard profiles that define the rules and procedures a specific device should use to accomplish a specific task. These profiles define activites such as wireless telephony, file transfer, and audio video distribution. When more than one bluetooth enable devices are in close proximity to each other, they form a Personal Area Network (PAN) and determine a communication between like devices. This allows for a bluetooth enable MP3 player to talk to a bluetooth enable computer and a bluetooth enable stereo in the same room, while the bluetooth coffee pot only talks to the computer.

WiFi (short for wireless fidelity) is a communications technology used in wireless Local Area Networks (LAN). WiFi is based on the IEEE 802.11b standard and can be used at distances up to 305 meters (in open areas) between the transmitter and the receiver. In comparison to bluetooth's 1 Mbs, WiFi can transmit data at up to 11 Mbs. Like bluetooth, WiFi also uses spread spectrum frequency hopping and operates in the 2.4 GHz range.

WiFi came out on the market for office use, enabling networks to be set up without the need to run cabling to individual computers. It is fully compatible with existing Ethernet technology with access points connected directly to existing networks. This allows peoples workspace to be reconfigured easily and allowes laptop users to do away with

network hookups when they moved around. For about $70 to $100 dollars the home user can buy a wireless modem/router to set up a home wireless network and an additional $60 would be needed for the wireless network card for each computer.. This hardware is made by companies such as Linksys, D-Link, and Netgear and can be purchased at most consumer electronic stores.

**Benefits of a Large Wireless Pipe**

With the large bandwidth provided by bluetooth and WiFi, both wireless technologies have the ability to revolutionize the way children interact with their toys and how the toys interact with the environment. Rather than small bit sized pulses that are currently transmitted through toys, voice, content, and environmental data will be able to flow to and from adequately equipped devices.

Imagine the following scenario. Sarah, a ten year old girl, walks into her bedroom after coming home from school wearing a pin attached to her shirt. The doll sitting on her bed wakes up, calls her by name and beckons her to come closer and give her a kiss. Meanwhile, the learning toy on her desk has already started to download the spelling words for the week, which Sarah's teacher uploaded to the web after school. Sarah's friend Kelly comes over with her doll, and wearing a very similar pin. The two girls say hi, and the two dolls say hi to each other by name and start a conversation. While the girls are playing, mom is downstairs, working on the computer, while occasionally flipping to a local web page to make sure both girls are still in their room. As the girls go downstairs for dinner, the dolls remind them that they still haven't studied their spelling words.

The above scenario is possible using existing WiFi and bluetooth technology. The bluetooth enabled pins the girls are wearing provide identification information and emit signals as they move around. The bluetooth enabled doll is then able to use proximity sensing to determine when the girl walks in the room and how far away she is. The girl's friends unique ID lets the doll know that there is more than one person in the room and from a past encounter remembers who it is. When the second bluetooth enabled doll authenticates with the Personal Area Network the first doll sees it and picks a preprogrammed conversation to initiate, both through voice for the girls to hear and via digital wireless communication so the second doll understands. The learning toy on the desk, which is equipped with a WiFi wireless LAN card automatically logs into the

school server and checks for any updates to the information for the girls classes. The learning toy, being on the same local network via it's bluetooth capabilities, with the dolls then sends a message to the dolls to make a verbal reminder when the girls walk away.

The advantage that bluetooth and WiFi would have in this scenario is there ability to transfer large amounts of information. Current, relatively inexpensive IR communication would be too slow for an application such as this, and have line of site problems. The RF communication used in toys now would not be able to transmit any data that was more than a handful of bits in length. Being WiFi enabled, the learning toy can have onboard software that can be programmed to download large chunks of web content just as fast as a personal computer could.

A second (possibly hidden) device in the room, WiFi equipped, could have an onboard webserver, which, as part of the LAN in the house, is also collecting information regarding any incoming signals from the pins on the girls shirts. This information is logged and turned into web content that can be viewed by mom, directly from the device using her personal computer. This allows mom to know if the girls have left the room.

Divices similar to the girls pins are already in development. The Wallet Alarm, a device developed by a Dublin Based banking application company employs a bluetooth card kept in a wallet. When the card is moved a certain distance away from another specified bluetooth device, an alarm sounds alerting the user. With this technology, you would never use your wallet. The bluetooth device, about the size, but a little thicker than, a credit card is small enough to be put into a wallet (Clark). With an implementation this small, an identifying and tracking tag for a child is not so far fetched.

Proximity sensing ability is already commercially available in a Sony Ericsson bluetooth enabled cell phone. With software called the Salling Clicker (no relation to the clicker technology mentioned in the first section) a consumer can use his cellphone to interface with Apple Computer's Applescript, a scripting language for Apple computers that allows

control of almost all functions of the operating system. This combination of bluetooth and operating system control allows the user to turn his or her phone into a remote for a presentation. Using proximity sensing the user can script their computer to turn music on or off as he or she enters the room (Salling Clicker). By adapting this technology to the dolls mentioned above, the scenario has the possibility to become a reality.

**A Wireless Solution**

In order to implement a new technology, costs must be looked at, both from the standpoint of price, but also in terms of development time. The amount of design and development time needed to implement a wireless solution into an existing product may be relatively short. A look at adding wireless communication to a handheld cartridge device, such as a Fisher-Price Pixter, or a Nintendo Gameboy can provide a quick introduction to what might be involved. For an application such as a two player game between two individual units within relatively close proximity such as car or a living room, bluetooth would be the best option to pursue. Given each toys price, the fact that it runs on four batteries and the short distances involved, the cheaper, short-range bluetooth solution would be a good pick.

There are a variety of bluetooth chipsets commercially available that could be implemented to fulfill this application. Due to the growing use of bluetooth, chipsets have come down to the $4 to $5 dollar range, which gets them close to being viable for use in a toy. Chipsets often add time to the development schedule because of the software needed make the various parts work together. This software, available on either a ROM or through flash memory is not necessarily error free. Chipsets can also require other supporting hardware which can add to the cost (angelseye2002).

The quickest, and easiest, although slightly more expensive way to implement bluetooth is to go with a one chip bluetooth module. The extra cost for the fully developed and tested solution is usually within $1 to $2 dollars. The BGB100 TrueBlue radio module, made by Phillips is a good example of a one-chip solution and would be easy to implement into our Gameboy or Pixter example. The module is 12.5 x 9.8 x 1.9mm, which is typical for bluetooth modules of this nature (Phillips, 2). It's small size would allow it to be placed into a small plug in cartridge, similar to those already used by Gameboy and Pixter. Although this chip requires an external antenna and a reference clock, it is designed to be a plug and play class 2 radio module and needs no external circuit components to work. The inputs constist of a connection to the three wire serial

bus, needing a data input, an enable input, and a clock input. For under $8 dollars and with little modification to the current circuitry, bluetooth could be added to an existing toy.

**Social Implications**

Although there are a few cost hertles that need to be overcome before bluetooth and WiFi become widely integrated into toys, there are also some social implications that may come about as a result of the increase of smart toys on the market. As with some of the developing technologies today, society must adapt and change to accommodate the changes. As can be seen with cell phones, they were originally very convenient as a "talk anywhere" technology, allowing the mobile phone owner to have access where ever service was available. Now that the technology is so wide spread and the user base continues to increase, cell phones have become a major public annoyance. Legislation has been past in many states to ban cell phone use while driving (unless a hands free device is used) and some areas have discussed plans to ban cell phone use in many public buildings such as Libraries and Courthouses.

With the emerging wireless technology that could soon become available in toys, the major social impact could be the safety of the child. Although there are potential hazards due to the EMF and radiation wireless devices can output, a more important safety hazard could be security. There is some amount of security for wired communication just because a person first needs physical access to the wire. To solve this problem with WiFi in particular, a security method called Wired Equivalent Privacy (WEP) is built into the protocol. Although it is not intended to be a full proof security scenario, WEP was designed to implement the same privacy available to wired communication to the wireless realm (Henry, 67). The main problem with WEP is that, because of it's difficulty to set up, is often left turned off.

The lack of security is a problem on it's own, but when children are involved, it could have serious consequences. The Children's Online Privacy Act of 1998 was adopted to address some of the issues regarding the capture of personal information of children through internet sites. The law now requires parental consent before a website can collect, use, or distribute information collected from a child.

The issue of child privacy and safety is even trickier with wireless communication, because the collector of the information may not me a legitimate source. The ability to listen in is much greater, and even somewhat harmless information obtained by an illegitimate source, such as a name and a favorite book, may be enough for a stranger to appear as a friend. Where proximity sensing has the ability to help a person keep track of their kid, it makes you wonder who else might be keeping track.

**Conclusion**

Although it was predicted that bluetooth toys would be the hit for the 2001 Christmas season (Walker), the technology has been slow to catch on in other consumer markets, leading to prices that are still too high. With the current technologies used in sensing and interaction in the toy industry, the integration of bluetooth and WiFi into toys seems like the next logical step. The advantages of bluetooth's lower cost and low power make it an excellent choice for playsets and handheld activity toys, and the speed and capacity of WiFi has potential application to the higher end learning and web based educational products. With the continuously decreasing costs of both technologies and with the development of security solutions in other industries, "playing" with bluetooth and WiFi is not far off.

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