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# Research on synchronization between smart toys and smart phones for classifying smart toys

Sugkyu Jung

*Dept. of Internet Contents, Honam University, South Korea*
*jsk@honam.ac.kr*

## Abstract

*Market of smart toys is showing rapid growth globally. Recently, new types of toys which can be synced with smart phones, so called smart toys, are being released continuously. As a result, products from RC cars with camera attached that can be driven and monitored using a connected smart phone to toys that would call kid's name once it has been entered through a mobile app. It has been confirmed that there are various way to connect those toys with mobile devices. In this paper, functions of smart toys are classified, and research on different synchronization methods of the toys sold in market as of July, 2017 are explained..*

*Keywords: smart toy, IoT, convergence, ICT*

## 1. Introduction

Lately, products from cars to appliances that can be connected to internet to give and receive information, so called IoT(Internet of Things), are gaining popularity. Most of IoT devices these days are being developed by adding internet connectivity to a current model which wasn't built with the function at first.

However, many IoT items are being created while overlooking any threats or issues that can occur from accessing internet. That is, those smart toys are filling up shelves in stores as new generation of toys that can be linked to smart phones. Like mentioned above, in current market, there are RC cars that a user can play with while watching the real time streaming from an attached camera connected to a mobile phone and toys which are able to call user's name by learning it from an app that stores such information. It is a fact that those products generally market children, thus interpreted as low risk items by customers who would not consider possible threats or precautions that ought to be reflected. To sum up, it is even more crucial for smart toys than other IoT devices to be enjoyed without customers having to worry about any serious hazards that might happen from network connection. Internet connection is a function that became fundamental in designing a smart phone. This means, syncing those toys and smart phones leads to the toys being connected to a network either directly or indirectly. Moreover, having an online status like this poses multiple security threats such as hacking and leaked personal information.

There are a few different ways to sync smart phones and smart toys, and each methods propose threats respectively that varies in severity[1]. What's more, once the toys are connected to internet with the synchronization,the risk of experiencing related issues magnifies. Since the seriousness of those problems are not yet fully cleared, it is essential to examine how two devices are linked. In this thesis, smart toys are classified, and research on different synchronizations of those toys as of July, 2017 is introduced.

## 2. Concept of smart toys and their classification

In general, smart toys refer to traditional toys integrated with IT technology[2]. Current trend of smart toys is revising or improving the original form of the toys using well-known characters since they are highly marketable. It is very much likely for a smart toy to include various ICT part such as sensors, motor, voice detector and antenna for wireless connection. If attaching any of these to a toy is technically impossible, then a brand new design would be established, considering to add those parts.

While the traditional toys involve less engagement from users, the smart toys are different in that it requires constant interaction with them. Through this kind of communication, users are able to utilize the toys to achieve their goals. Overall, it can be said that smart toys hold more education value than conventional toys in that users can engage in better[3][4].

In spite of the potential which smart toys suggest, a concept of those devices has been constructed yet. Furthermore, there are no industrial policy from government for smart toys available. Currently, South Korean government defines a toy in Annex 6 in notification number 2015-108 from the Ministry of Industry, Trade and Resources[5].

**Table 1 The Classification of toys**

| Separate criteria | Detail classification | Case |
|---|---|---|
| Operability | Actuating toys | Moving toys (using motors only) or windowed toys |
| | Non-functional toy | All toys, not operated toys |
| Age of use | Young and Child toys | Age below 3 years of age |
| | Toys for children | Age of use 3 years or younger than 8 years |
| | Toys for young students | Age of use 8 years or older |
| Function and properties | Activity toys | Swinging, slide, seesaw, rotating rides, climbing apparatus, etc. |
| | Art craft toys | Drawing tools, staff members, production kits, baking kits, sewing kits, sewing kits, etc. |
| | Learning toys | Language, math, science, music, etc. |
| | Puzzle toys | Pictures puzzle, 3D puzzle, assembly models, Chilgyo Nori, etc. |
| | Party toys | Costume suit, masks, hats, hats, and clothing, etc. |
| | Rag doll | Stuffed toys stuffed with soft, stuffed toys like teddy bears. |
| | Functional toy | A toy with a microscope, telescope, etc. |
| | Game toys | Board games, card games, dominoes game, bingo games, etc. |
| | Passenger toys | Mechanical or electrical functions such as automobiles, motorcycles, and bicycles |
| | Projectile toy | Bow, guns, and toys, toys, etc. |
| | Role-playing toys | Playing house, banking, phone games, shopping, etc. |
| | Toys for musical instruments | Keyboard, melodion, xylophone, tambourine, castanet, drums, marakass, ocarina, etc. |
| | Exercise toys | Softball, rubber ball, plastic baseball bat, tramblin, plastic weights, etc. |
| | Infant toys | Rattler, Chicker, infancy brace, etc. |
| | Block toys | simple assembly block, complex geometry block, etc. |
| | Dummy toys | models, animal models, etc. |

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|---|---|---|
| | Magnetic toy | Magnet block, magnetic board, magnetic fishing, etc. |
| | Controlled toy | Cars, airplanes, ships, etc. Controlled toy |
| | Furniture toys | A toy made from a dresser, drawers, rack pads, tables, chairs, etc. |
| | Other toys | Water pistol, soap bubbles, hand-handling, key ring, balloons, etc. Non-participation. |

According to the Annex, a toy is, "a product or a material that is clearly used or designed for children under 13 to play with. The expression, 'play with', here can imply intended usages as well as misuses that can be presumed rationally.". Although the smart toy market is booming fast, the official definition of government does not even set a separate category for it.

It is evident that current classification of toys does not reflect on smart toys. Following four categories are classification of smart toys that has been suggested by M. L. Martin-Ruiz[2].

**Table 2 Features of Smart Toys**

| | Block type | Control type | Conversational type | SW training type |
|---|---|---|---|---|
| **ICT Technology** | Smart Blockage, Wireless, Motor, display | Wireless communications, motors, robots, drones, etc | Voice recognition smartphone video transmission | MCU, Arduino, wireless communication , motor |
| **Interactive mode** | Block, Connection | User control | Artificial intelligence dialogue | Coding, EPL |
| **Outcome Effects** | Personal creation | Toys, robots, drones and adjustments | Communication | Coding experience learning |
| **case** | KIST Smart Toys, Cube Lloyd | Celto, RC car, robot, drone | OHaNAS | Lego mind storms, myxaop |

## 3. Research on smart toys

A smart toy is a fairly new concepts, and it is still indefinite to confirm what functions are needed in order to class a toy as a smart toy. In this thesis, for the sake of defining much clearer concept, a toy that uses next three synchronization methods is stipulated as a smart toy while focusing on the ordering party within the connection.

① S2T(Smart phone to Toy): Once a smart phone gives out an order, a toy receives and conducts it accordingly.

② T2S(Toy to Smart phone): Once a toy gives out an order, a smart phone receives and conducts it accordingly.

③ Interactive: A smart phone and a toy interact bilaterally and conduct orders from each other.

For this thesis, as for July, 2017, because it is difficult to decide whether a commercial product is a indeed a toy using a current standard, items used for researches are ones registered under "Toy" category in online shopping malls.

The online stores visited to access different products stocked both new product in market and old ones, but in order to research on products affecting the current market, only newly released toys were examined. Also, data of the goods were collected by using "Smart phone" as keyword to search them. As a result, total

98 kinds of toys from 13 companies were selected to be studied.

**Table 3 Smart Toy's Interconnection Method**

| Year of sale | kind | S2T | T2S | Interactive |
|---|---|---|---|---|
| **2013** | 1 | 0 | 0 | 0 |
| **2014** | 0 | 0 | 0 | 0 |
| **2015** | 1 | 0 | 0 | 0 |
| **2016** | 20 | 8 | 4 | 2 |
| **2017** | 67 | 5 | 1 | 0 |
| **Unknown** | 9 | 0 | 0 | 5 |

The research was done by using various synchronization used for the toys, which could be gathered from instructions listed on the toy companies' official websites. However, not all products offered a clear instruction on synchronizations, and in this case, it had to be assumed based on reviewing given direction technically. For example, if the manual warned putting smart phone speakers near the mic in the toy can cause uncomfort depending on people, then it was presumed that S2T connection with The Mosquito had been applied.

Table 3 shows result of the research. Among 98 types of toys, there were 25 types of smart toy. Also, there are 13 kinds with S2T connection, 5 with T2S and 7 with Interactive.

## 4. Conducting the order from the synchronization

Those 25 smart toys from the research uses one of following methods.

### 4.1 S2T

① Order delivery through The Mosquito
An order from smart phone to toy is converted to high frequency sound(the mosquito). The sound emitted through smart phone speaker is received by toy mic and the toy conducts the order.

② Order delivery through screen
This method uses a smart phone screen to deliver orders to toy. The researched toy was able to change its facial expression without being turned on by optically processing the phone screen when placed on top.

③ Order delivery through Bluetooth speaker
A toy becomes a Bluetooth speaker and can be paired with smart phone. Orders from smart phone are delivered as voice to be entered into the paired toy.

### 4.2 T2S

① Order delivery through touch
When a touch screen of smart phone is physically contacted by toy, it activates the phone. In this case, it is required to touch a particular area of the touch screen by manipulating the toy.

② Order delivery through entering texts
A toy transmits information to smart phone in sound. The transmitted sound data can be delivered to the phone by inserting an aux cable included with the toy into both parties.

③　Order delivery through The Mosiquito

A toy transmits information to smart phone in high frequency sound(The Mosiquito). The transmitted sound is emitted from the toy speaker, and smart phone mic receives it.

④　Order delivery through Bluetooth

A smart phone and toy exchange information bilaterally through Bluetooth pairing..

## 5. Research on internet connectivity

With the 25 types of toys, a research on whether internet connectivity would affect synced toys' performance has been done.

As same as previous research, instructions listed on sellers' official websites were mainly used as references. For example, if it says that once application is installed, there is no need to have internet connection in FAQ section of the website, then the toy was classified as ones that does not require network. In the end, there was only one type that needs uninterrupted internet connection. For this particular model, data that users entered into the application is sent to an external server, and then once that is fully processed, the phone receives the information again from the server. Eventually, the mobile sends to a designated toy.

## 6. Final contemplation on characteristics and synchronization of smart toys

From the researches, it has been found out that one-way sound synchronization and bilateral synchronization with Bluetooth are the two most prominent methods for smart toys. Reason for this trend can be easy installation of those methods' and importance of price competitiveness in toy industry.

### 6.1 Easy installation

Most of products that have been used in the researches target customers from infants to children. That is why it was designed as simple as it could be so that youngsters would freely control settings.

For sound synchronization, even though the app was intended for adults to install it, using the app itself was very easy. It only required user to open the app and place the smart phone around the toy, and two devices would connect. That is, putting the phone in certain area means putting phone speaker or mic within the connection range of toy speaker or mic.

For Bluetooth synchronization, both app installation and initial setting are intended for adults to take care of. As for the setting, mostly it only required pairing each party in Bluetooth setting, and there are ones that ask for 4-digit pin and ones that do not. Once this has been done, the smart phone would automatically pair with the toy, so users do not need to worry about re-pairing repetitively.

Other than them, order delivery through S2T with screen and T2S with touch are identical to sound synchronization except for installing the app in that placing a smart phone and toy in certain place is the most substantial step.

To summarize, researched toys have fairly simple setting. There is one simple and easy way that was not included in the research, which is wireless LAN connection. For this, devices use automatic setting system such as WPS[6] and manufacturers' own AOSS (Air Station One-Touch Secure System)[7]. However, there are no toys using wireless LAN connection this time, presumably due to 'low retail price', which is explained next.

### 6.2 Low retail price

Like mention above, toys that were researched market children. These types of toys are generally sold in humble price, and it is difficult to add any functions that would raise the price. Looking through the prices, it has been confirmed that average price of toys without synchronization function is 25,000 KRW. On the other hand, toys with sound synchronization were around 45,000 KRW, which is 1.6 times more than former. Also, average of ones with Bluetooth connection was 130,000 KRW, which is 5.3 times more.

Among many current educational toys, there are a number of those with speaker and mic, so in this case,

if companies add synchronization with mobiles additionally, using existing parts, re-invention is reasonably cheap. However, with Bluetooth, it is not possible to keep the existing parts, and required to add network module to toys. Consequently, Bluetooth connection is only applied with high-end toys with high retail price.

## 7. Conclusion

Throughout this thesis, smart toys have been classified according to their functions, and with those sold in market as for July, 2017, synchronization methods to smart phones has been analyzed. As a result, it has been confirmed that most toys adopt sound synchronization and Bluetooth connection. The reason for this trend is both easy installation and low retail price, which is commonly requested by consumers from toys.

Although above points have been covered, it is true that analysis on possible threats and solutions has not been suggested. Therefore, in future, there needs to be a risk assessment of each connections that have been introduced in this thesis. Issues that can occur from syncing toys and phones are ; leakage of personal details saved in toys, hacking of toys from external source, hacking of smart phones using connected toys, and it is my wish to examine how preventable these toys are.

Recently, it is easy to see brilliant IoT technology innovation within toys. For example, in August, 2016, a battery that can be synced with smart phone, using Bluetooth[8]. That is, by using this, it is possible to activate synchronization between toys and smart phone without remodeling the toys that uses conventional batteries. There are diverse functions included in the battery, and one is controlling speed of RC car by linking the angle of smart phone and the amount of battery output. Just like this, the trend in toy industry is transitioning rapidly. Therefore, effort to identity current circumstance should be given continuously.

## References

[1]  Jun-Won Ho. Probabilistic Analysis of Code-Reuse Attacks and Defenses in IoT(2017). IJIBC 17-1-4, pp24-25.
[2]  https://www.ipa.go.jp/files/000052459.pdf(2016).
[3]  M. L. Martin-Ruiz, M. A. Valero, M. Linden, S. Nunez-Nagy and A. G. Garcia, Foundations of a Smart Toy Development for the Early Detection of Motoric Impairments at Childhood. International Journal of Pediatric Research. (2015). Vol.1, No.3, pp.1-5.
[4]  Nong-Jun Li, Kee-Hyun Choi, Kyung-Soo Jang, Dong-Ryeol Shin. RFID-based Secure Communication for Smart Device in Future Home Network Environment(2013). IJIBC 13-1-5. pp18-19
[5]  N. Kara, C. C. Aydin and K. Cagiltay, Investigating the Activities of Children toward a Smart Storytelling Toy. Educational Technology & Society. (2013). Vol16, No.1, pp.29-43.
[6]  M. L. Martin-Ruiz, M. A. Valero, M. Linden, S. Nunez-Nagy and A. G. Garcia, Foundations of a Smart Toy Development for the Early Detection of Motoric Impairments at Childhood. International Journal of Pediatric Research.(2015). Vol.1 NO.3, pp1-5
[7]  Notice of Ministry of Trade, Industry, and Energy No. 2015-108, Safety Standards for Children Products, Korean Agency for Technology and Standards.(2015)
[8]  Wi-Fi Alliance: Wi-Fi Protected Setup, https://www.wi-fi.org/ja/discover-wi-fi/wi-fi-protected-setup.
[9]  BUFFALO:http://buffalo.jp/aoss/top.html.
[10] http://mabeee.mobi