AEEM 6099 Systems Engineering & Analysis

Shopping Assistant System

Main Project - Milestone 1

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1. Project Description

This project proposes a shopping assistant system aiming to help international tourists achieve a better shopping experience in big malls like Super Brand Mall (SBM) Shanghai. A mobile system integrating with information service will be developed for assisting the international tourists to do shopping in big malls. Thus, the system will be able to provide convenience to international tourists and save their time on a tight shopping schedule.

2. Project Summary

2.1 Name:

Shopping Assistant System

2.2 Team:

Company "YY" (Service Solution Provider)

2.3 Customer:

International Tourists (in big malls)

2.4 Problem to Solve:

International tourists usually have a tight schedule and waste a lot of time on searching right information, even lost their way in big malls as they are in a strange place surrounding by people who do not speak their native language. This project is aiming to improve the shopping experience of international tourists in big malls, like SBM Shanghai by making their shopping convenient and efficient. And the same solution could be applied to public places where the international tourists usually visit, such as airport, train station, and amusement park.

2.5 System-of-systems Context:

This project will develop a system for providing unique experience to international tourists, and will benefit big malls, airports, train stations who want to attract more international tourists, further, to improve the image of a tourist city.

2.6 Goal and Objectives:

The goal of this project is to build a system to help improve the shopping experience of international tourists in big malls like SBM Shanghai by making their shopping convenient, time saving and energy saving. The system shall be easy to be interacted with to reduce the wasting effort caused by communication in different languages, finding the right information of desired product and service, finding the correct position of the store they want to go and carrying the heavy bags during long hour shopping.

3. Motivation

3.1 Yufeng Sun

I am a student in AEEM and my research interest is robotics. I choose this project because I would like to practice the system thinking in my interested area. This practice will benefit my study and research on robotics in future.

3.2 Yuhan Liu

As a customer usually shopping in Big Mall and find it hard to find some spots inside and search information about products, I choose this specific project to solve this problem I interested in. Since I took the robotics course, I have a lot of interest in this field and I believe it will practice my system thinking skills as my track is system engineering.

3.3 Team

Today's shopping malls are shifting their roles to service providers in order to survive in the competition with online shopping and other shopping malls, such big malls usually require a lot of time to explore, and the complexity of internal environment makes the shopping time consuming to millions of international customers. For example, SBM Shanghai is a huge mall with 13 shopping floors and more than 400+ brands. The place is a hive of activity with many options for food and entertainment. Thus, it requires a lot of time to explore the places. Wide range of options attracts customers, however saving time is one of the main purposes of customer to do shopping in a mall. In addition, language service is one of the important factors that international tourists will consider for choosing a shopping destination. So, we think the shopping experience of millions of international tourists could be improved by using some kinds of device that could assist them to do shopping.

4. System Operational Requirements and Maintenance Concepts

In this project, we (Company YY) are responsible for designing, constructing and deploying the shopping assistant system.

4.1 Operational Requirements

The operational requirement for the shopping assistant system could be categorized as follows:

4.1.1 Mission definition

Prime mission

The prime mission of this project is to develop a shopping assistant system integrating with information search functionalities which is aiming to improve experience of international tourists when they are doing shopping in big malls, like SBM Shanghai. International tourists usually have tight schedule, the shopping assistant system shall be used to address the main problems during their shopping in the big mall. The system will be integrated with advanced user interaction system to process end-users' requirements, such as navigating them to stores or any other spots in the mall where they want to go, providing plenty information about products and services when they give a search criteria and providing interaction in their native language. And the system shall be developed to be able to carry end-users' bags. With these functionalities, the system will be able to make the shopping experience of end-users more convenient and efficient.

Dynamics of operating conditions

- Complex environment

Big malls are places where may have floors and escalators, and sometime may be crowded, the shopping assistant system shall be light-weight and in appropriate small size so that it can be maneuvered conveniently without introducing troubles. And it should be easy for end-users to access, to rent and to return during their whole shopping time.

- Different requirements from end-users.

International tourists may have different requirements on the system, someone may want to use most of the functionalities and someone may only use one of these functionalities. So the system should be developed to be flexible to satisfy different requirements without introducing other troubles.

- Information update

International tourists require information that is accurate and updated, so the system shall be able to provide latest information related to the products, services and facilities to the end-users.

- Unexpected usage

End-users may leave the device along while they are doing other things, the device shall be able to track the end-user, and be able to send a warning or a reminder to the end-user once they are far away from each other or in an unexpected situation.

4.1.2 Performance and physical parameters

As the shopping assistant device will be developed to help international tourists save their time and make their shopping convenient, there are some critical parameters that need to be monitored to ensure that the device is functioning as it is designed to. Briefly listed as follows:

- Mean time between failures (MTBF)
- Mean time to respond (MTTR)
- Speed of autonomous run
- Tracking distance
- Accuracy of navigation
- Payload
- Battery life
- Weight
- Size

In order to make the system easy for end-users to access, the MTBF and battery life will be monitored and make sure the devices are able to run during the business hours without any failures. The Speed of autonomous run and tacking distance will help end-user in the scenario that they are busy on other things and don't manually control the device. Accuracy of navigation will save the time of finding the stores or places that the end-users want to go. And the payload will be designed to maximize the capability of

carrying bags for the normal cases. The MTTR is the indicator of how software system work and will be important to the user experience for the interaction with the system, the system should respond to users' input in a reasonable time. The weight and size will determine how user to maneuver the device when they switch the autonomous mode to manually control mode in some complicated situations where the device cannot perform autonomous move.

4.1.3 Operational Deployment / Distribution

- Quantity of equipment - 200~400 shopping assistant device is almost enough for the Super Mall like Super Brand Mall (SBM) in Shanghai which has 600 million tourists per year. As not so many people will buy things in the mall and if only 10% (which is very high as usual) of customers want to use that, the quantity of our devices is enough to cycle use during the opening time of the super mall. And the normally use time of every device is about at least 5 years before sending back to recycle.

- Software - There are three distinct systems which need different software. The high-level overview of these software are:
  - ✓ The shopping assistant device use this drive control system for moving following the customers automatically. It may need Bluetooth in every device. It can do contribution to customers' shopping more convenient and relax.
  - ✓ The service system of the devices can give several kinds of service to customers including navigation, searching information, translation and recommendation which need different software like GPS for navigation.
  - ✓ Software in the device should be interaction system to make connection with end-users and let customers easily use it. As the device should provide voice service during the experience customers using it, like navigation, translation and giving recommendation, end-users can easily get response by connecting the bluetooth headset.

- Personnel required - The super mall who use this device need train people to know the basic operational knowledge of the device to avoid the situation that some customers have questions about how to use the devices. Also, they should provide service to customers in case they return the device everywhere and it did not move

to the nearest station on the same floor. What' more, if the device be broken or has any other problems, they could manage and return them to factory to fix.

- Expected geographical location - The device should be easy to access so these should be mainly put in front door of mall and underground parking stations which can be easily get and return when customers get out and into the mall. Also to guarantee the availability of the device, the mall should put stations in every floor to let customers return the devices very conveniently. To make end-users have the service which quickly add the time to continue using it, the device should provide easy way for customers to pay using card and include different time plan for customers to use at first. It could charge immediately and automatically when it is returned to any stations and stay here between 10 pm to 10 am.

- Distribution of software - There may be all the three kinds of system of software on every dependent device to support and manage the interaction of the device including navigation, translation, driving itself and information searching. It is very important that all the devices share store information in mall and update it by the same network platform.

4.1.4 Operational Life Cycle

Program schedule

System phase	Timeline
System planning, design and prototype	3 months
Phase I Construction	3 months
Phase I Testing	4 weeks
Phase II Operation and maintenance	5 years
Phase III Recycle and disposal	4 weeks

Total inventory profile through life cycle

We will make 200 devices in phase I and test all the devices before deploying. We will deploy 150 devices to SBM Shanghai with distributing them to 7 floors. The other 50 devices will used as replacement during maintenance.

Who will be operating the system?

We (Company YY) will responsible for the system planning and design. Once the design is completed, a 3rd party manufacturer will be involved for fabrication and we will co-work with the 3rd party manufacturer for the details of the devices, such as the material, hardware etc. Meanwhile, a software company will be involved as the software system vendor. After the device is completely built and software system is developed, we will install the software system on the device and test the device in the testing environment where is for simulating typical situations in the mall. After the devices pass the test, they will be deployed to SBM Shanghai, and there will be some trainings about how to use the device and do daily maintenance for staff from the mall as they will be responsible for the daily operation and maintenance on the system. Once the devices are broken or unable to use, they will be sent back to us, and we will check and repair them, or simply replace the devices. We will decide if the devices need to be disposed based on the level of damage. If the devices cannot be repaired and need to be disposed, they will be sent to a 3rd party vendor who is for recycling and disposal.

4.1.5 Utilization Requirements

The devices shall be used in business hours of the mall, typically from 10:00am to 10:00pm, 12 hours in total. So, the devices shall be fully functional during this period. Daily maintenance will be scheduled in 10:00pm to 11:00pm after the business hours.

Once end-users enter in the mall, on the main entrances, they shall find these devices easily. With easily paying for rent, they could unlock the device and start their shopping. The devices shall have two control modes, one is for manually control when the surrounding situation is complicated, and the other is for autonomous move when the surrounding situation is simple and clear. The devices shall be able to track the distance between itself and end-users in case of the end-users are too far away from the devices or in some other unexpected situations. The devices shall be able to send a warning or reminder to the small piece receiver hold by the end-users. Once the end-users want to stop shopping and leave, it shall be allowed them to drop the device to the nearest

appropriate spot by simply returning the receiver to the device which means the end-user is leaving.

The device shall be able to check the status of itself. If it is not in use, it shall be able to find the nearest spot and autonomously move itself to that spot (usually on the same flow). In case there are too many devices in one floor, the staff in the mall will redistribute devices to other floor. All these works are for ensuring that the devices are available and easy for end-users to use.

4.1.6 Effectiveness Factors

- Cost system effectiveness
- Operational availability
- Dependability
- Failure rate
- Facility utilization
- Operator skills
- Task accomplishment

4.1.7 Environment Factors

The big malls like SBM Shanghai usually contain floors and escalators, and sometime are crowded. The device shall have capability to handle the different situation. So, the device shall be developed to have two control modes, one is autonomous control which is for release the hand of the end-user and keep following the end-user by tracking the distance between itself and the end-user. The other is manually control which is for the complicated surrounding situation and end-user could manually control the device, when they are riding the escalator or elevator, or in a narrow place.

And the device shall be able to detect obstacles when it is in autonomous control mode.

4.2 Maintenance Concepts and Repair Policies

4.2.1 Major level of maintenance

Criteria	Organizational	Intermediate	Supplier/Manufacture

	Maintenance	Maintenance	r Maintenance
Done where	SBM Shanghai, the Mall which is the operation site	Company YY	3rd party vendors
Done by whom	Staff from the mall	Technical support department	Staff from 3rd party vendors
On whose equipment	On the device and the mall's equipment for paying and charging the battery	On the device and the equipment for update the software system	On the device and the equipment of 3rd party vendors
Type of work accomplished	· Clean · Redistribute · Charge the battery · Test functionalities · Change battery · Change specific parts	· Update software system remotely · Check and test the functionalities of the device generally	· Repair the hardware · Repair the mechanical parts · Fix software system bugs · Disposal · Recycle

4.2.2 System operational and maintenance flow
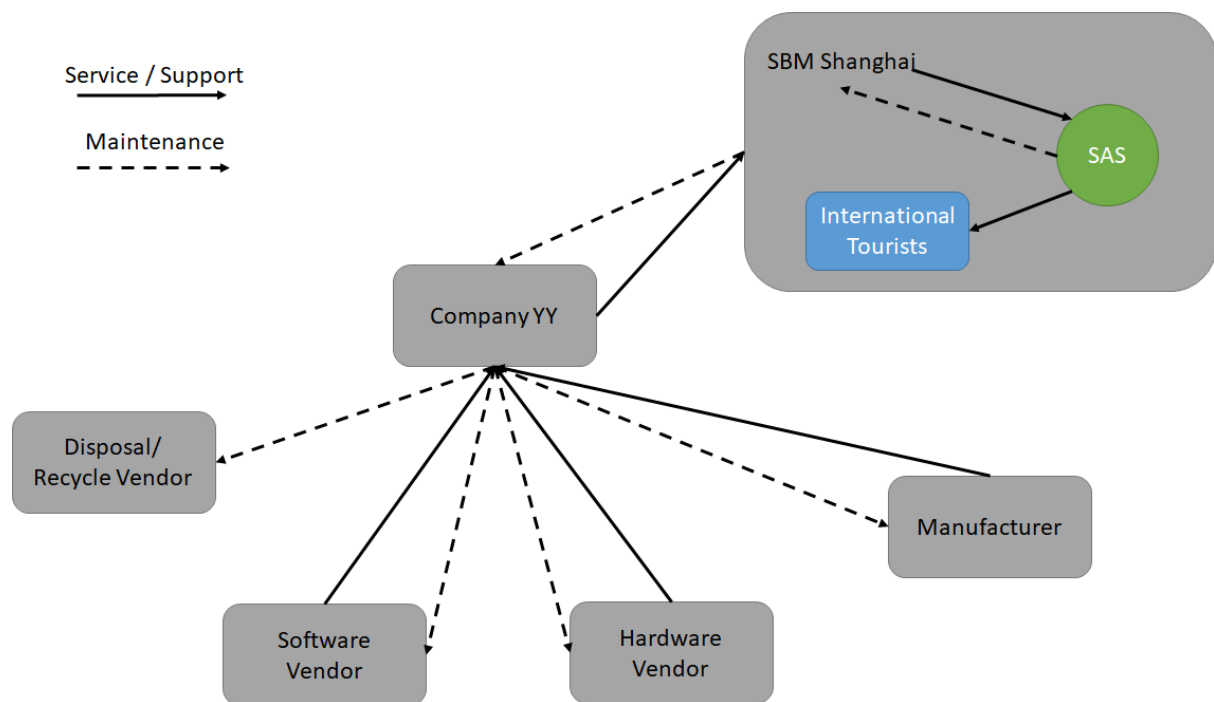
Company YY will responsible for design and develop the system, then work with the software and hardware vendor as well as the manufacturer to fabricate the system and then test and deploy to SMB Shanghai, the system eventually will serve the international tourist. SMB Shanghai will be responsible for the daily maintenance for the system. In case there are damages to the system, Company YY will responsible for the support and decide if the system needs to send to hardware, software or manufacturer supplier for repair. In case the system is unable to use due to either damaged or expiring the guaranteed date, the system will be disposed by the recycle vendor.

5. Context of your system's function in the larger System-of-Systems

5.1 Community infrastructure

5.1.1 Existing infrastructure

In the bigger context of shopping in a mall, we have already used the foundation services like electric supply, computer resources, the internet, payment system, mobile phone as well as some people for shopping guide.
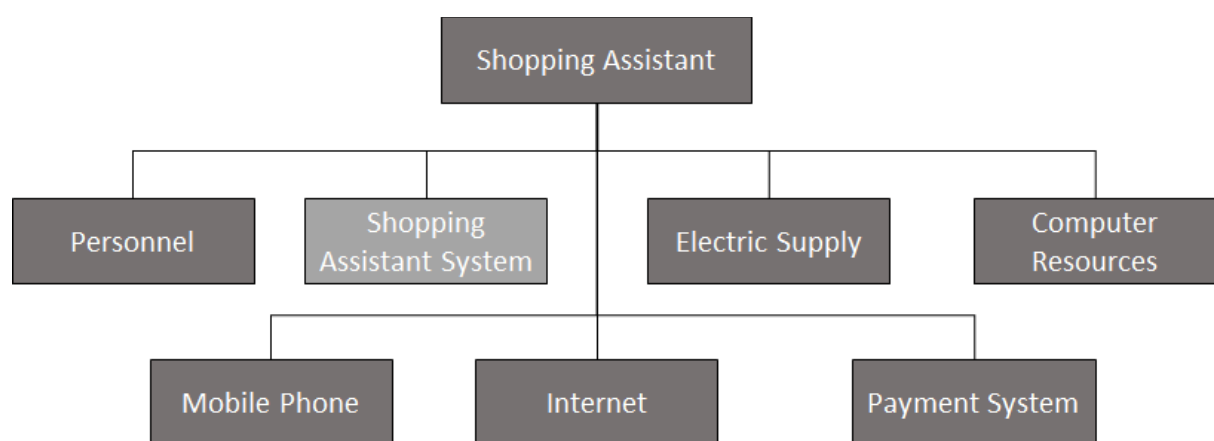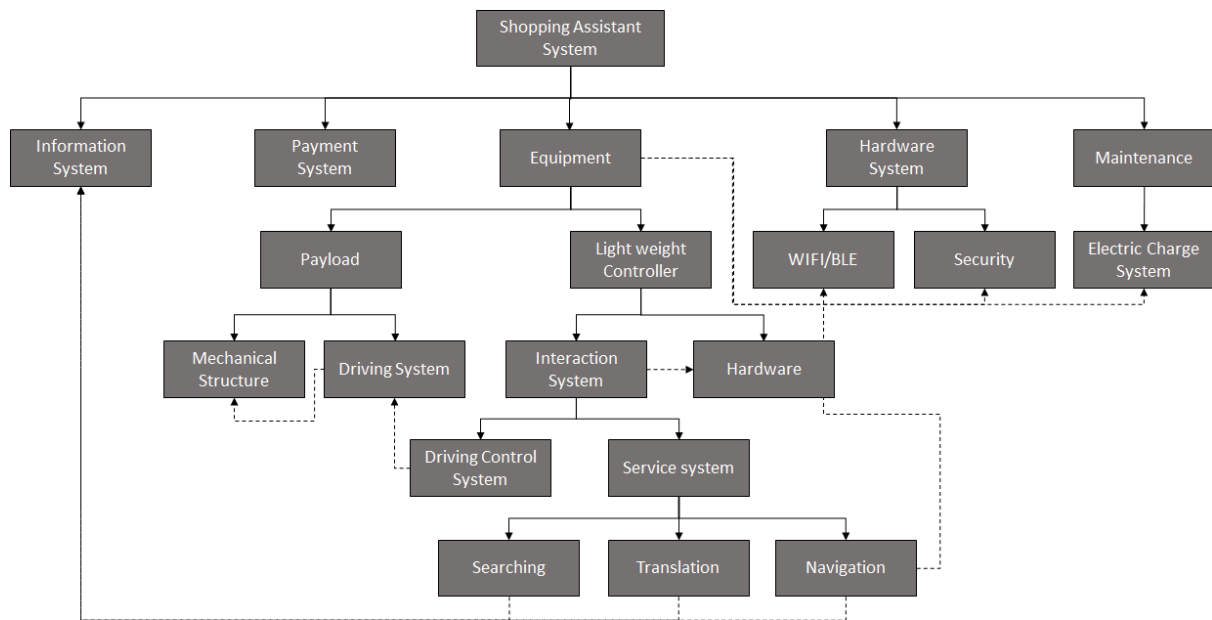

The electric supply, Internet, payment system and computer resources are the base systems that our own developed shopping assistant system will use. Mobile phone is personal device that usually could be used to search the information of product and service, even perform the navigation in the mall through the available floor index.

Personnel are the staff in the mall who will give customers suggestion when they have questions about the store position, service availability and etc. They act like help desk where customers sometime can get translation service from.

Based on some of the foundation systems, the shopping assistant system we proposed will combine most of the other systems in one device to address the major requirements from International tourists who will do shopping in the mall. And the system consists of major subsystems listed as belows

- The information system
- The payment system
- The shopping assistant equipment
- The hardware system
- The maintenance system

Shopping Assistant System

Information System — Payment System — Equipment — Hardware System — Maintenance

Payload — Light weight Controller — WIFI/BLE — Security — Electric Charge System

Mechanical Structure — Driving System — Interaction System — Hardware

Driving Control System — Service system

Searching — Translation — Navigation

Information system

Information system is a subsystem in shopping assistant system. It consists of computer resources and mainly provides the capability of responding the requirement of information search. It may have a database for storing and updating the information of product, service and facility and other aspects which are useful to the end-users.

Payment system

Payment system will provide easy payment methods for end-users based on the existing technologies and systems such as credit card, mobile pay an etc. There may be some design works in the payment system specifically for the shopping assistant system, for example, it has to deal with the foreign card as well as currency. The goal of these works is to provide a seamless experiences to end-users that make them feel like paying in their own country.

Equipment

The shopping assistant device are the main tool end-users will use in their shopping. The device is the main entry of the services. End-user will use this device to search information, navigate themselves in the mall, translate the speaking in and out, as well as carry their bags. During the operation, the device will work with other systems to perform the tasks that will address the requirements from end-users.

To meet different requirement from end-users, the shopping assistant device will be designed and developed as detachable parts, with one of a light-weight controller and the other is payload carrier. the light-weight controller could connect to the payload

carrier and track and control the payload, and the controller will be used along as it will provide most of the requirement from end-user, such as it could be used to search information, it could be used for navigation, and it could be used as language translation device. The payload carrier is only used to carrying bags. In case end-users want to use all the services, they could pay for using the controller and the payload carrier. For other cases, the controller could be used only.

With the controller, end-users could interact with the system to do information search, navigation and language translation. Thus the system should installed with interaction system which will control the sub software system like the payload carrier control system and services system for searching, navigation, and translation. The searching, navigation and translation will use the data coming from information system.

Hardware

Hardware system are subsystems that support the functionalities that the device provide to end-users. This system consist of WIFI and Bluetooth for connecting devices for the information transmission, as well as devices for security concerns. This system only covers the hardware devices used in the mall and usually are fixed devices.

Maintenance

Maintenance system is for daily use, for example the electric charge system which will be used for recharge the equipment of shopping assistant system.

Maintenance system also include people who will do the cleaning or redistribution that will make the system fully functioning every day.

5.1.2 Function flow diagram

Below chart is the high level function flow of the shopping assistance system used in daily operation.
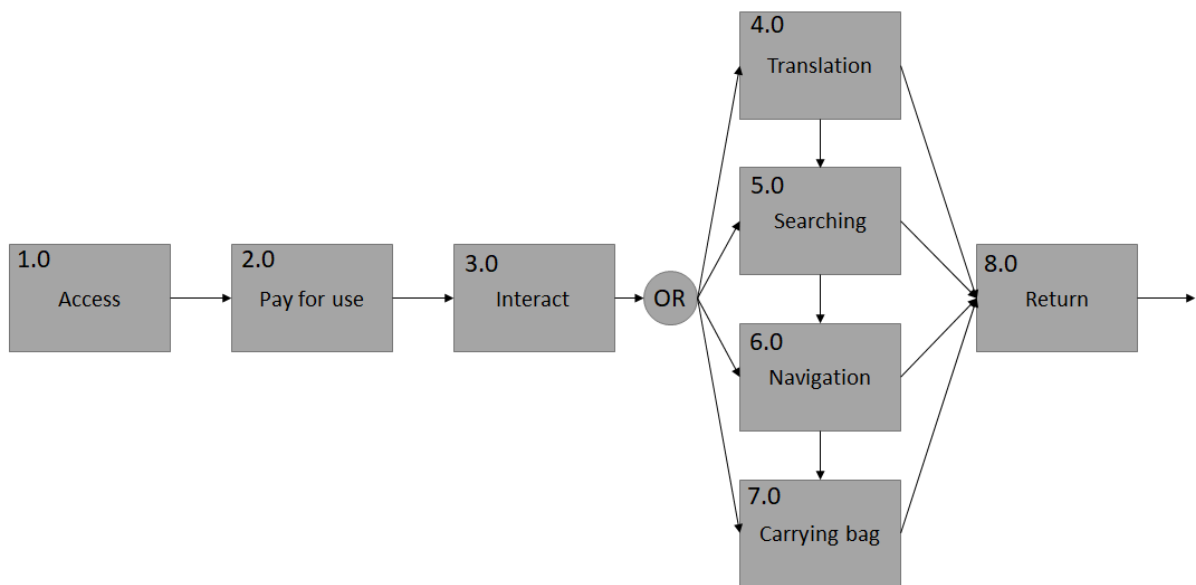
The high level function flow will start from access, where end-users interact the system firstly, then with the function pay for use, they will start the system and use the interfaction system to operate the device and perform the tasks like translation, searching, navigation and carrying bags to address their problem, finally they will easy return the device after they complete the shopping.

The lower level function flow in interact is
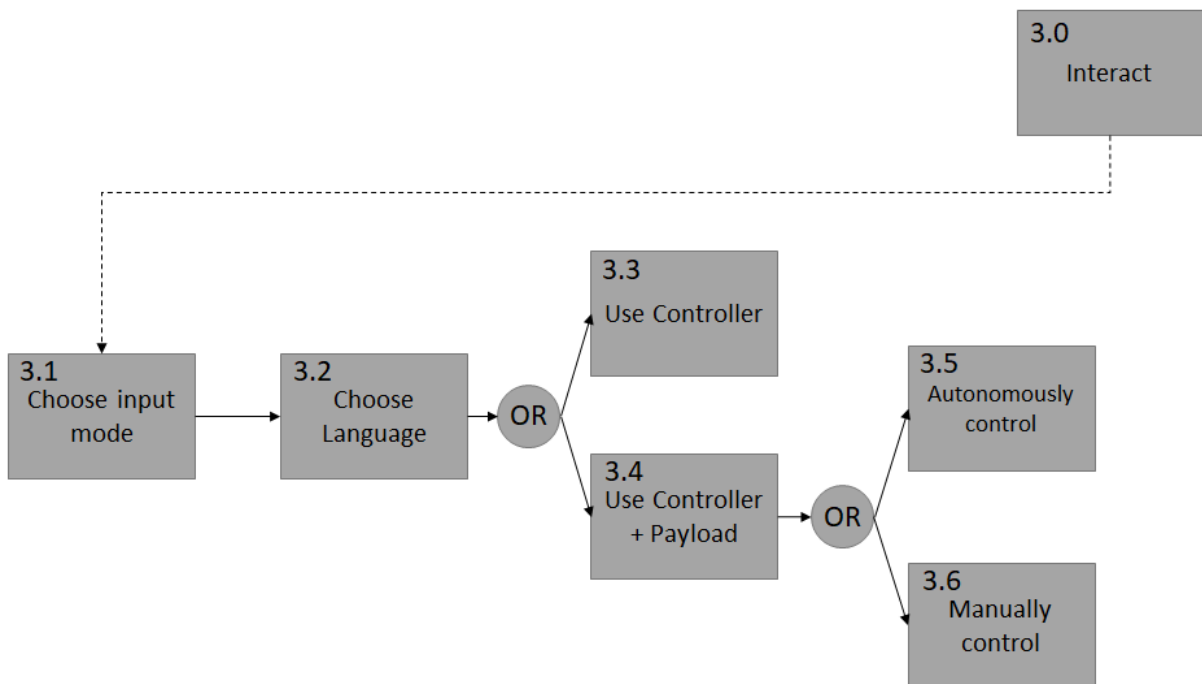
During interaction with the device, The international tourist will be asked to choose the input mode (voice input or handwrite) for best matching their preference and conditions. And then choose a language to make their trip as at home. Then they will use

either use the controller only or use both the controller and the payload carrier based on their needs. If they use payload, they will be asked to choose manually control the payload carrier or autonomously control it given the condition of the complexity of the environment and their preference.

The lower level function flow in searching
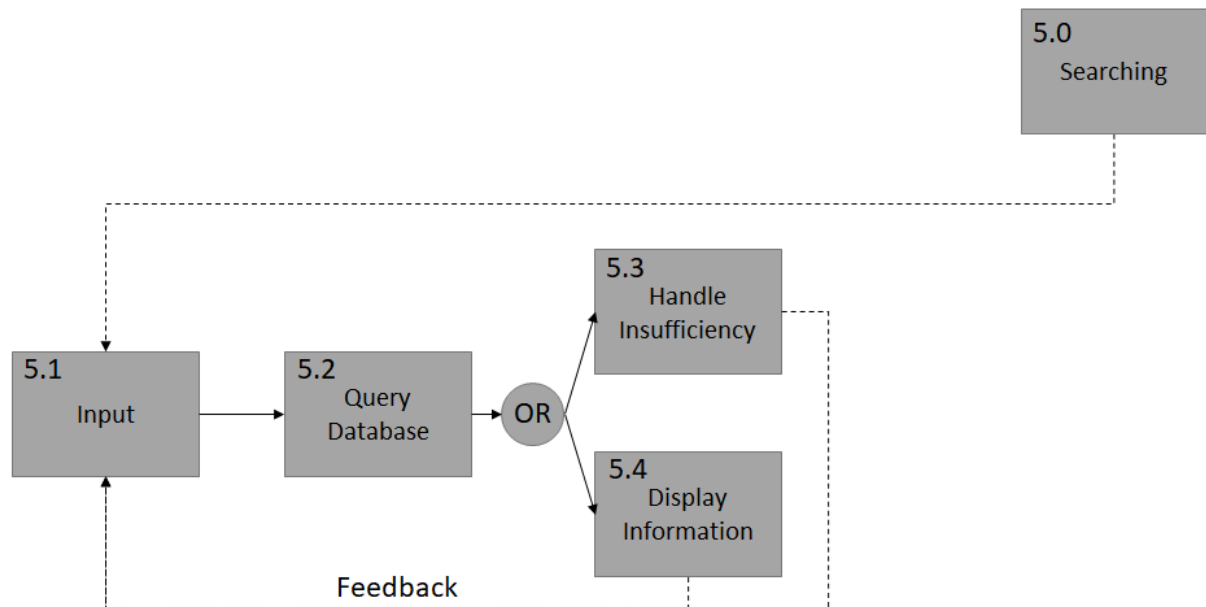
When end-users use the searching function, the first thing they need to do is to interact with the controller by inputting the searching criteria, then the system will query the database to get the search result. if the database return insufficient data, we need to let end-user know and suggest them to change the criteria if needed, but most time the database should return the correct information for the users searching criteria except the criteria is invalid. The information will be displayed on the controller for end-users to view and select for further searching.

The lower level function flow in navigation is
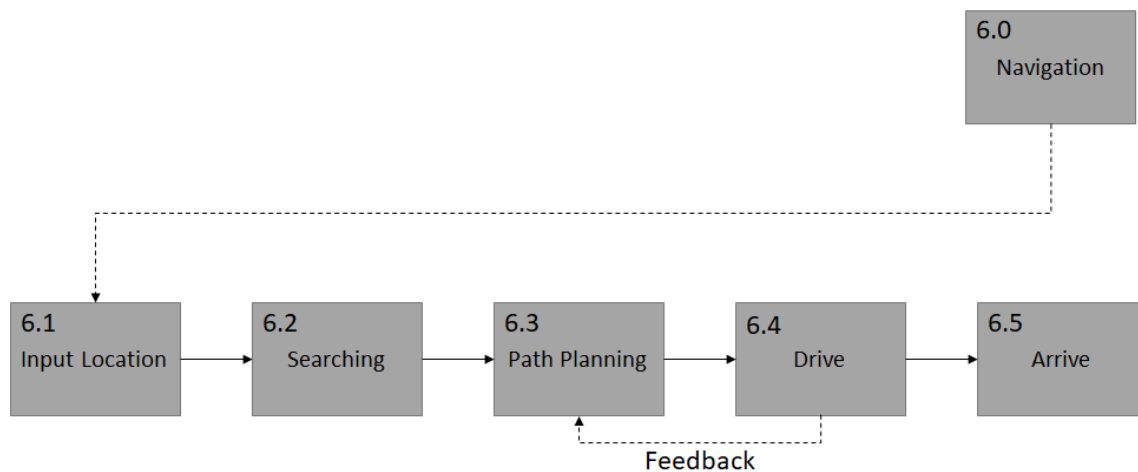
In navigation, same as the searching, end-users need to interact with the controller by input the name of the spot they want to go, the system will searching the database and find the information of target spot. The give a path planning with the information. Once the end-user confirmed the path. The system will drive the payload carrier if it is used in autonomous control mode, or the system will display the direction and guide the end-users to the target spot. during the whole navigation, the system will receive the updated information from information system and the status of the controller itself for updating the path planning and estimating the remaining time and distance from the current spot of end-users to the target spot, so that the end-users could get the latest information of the system for make decision further.

5.2 SOS configuration

5.2.1 Operational Requirements of the SoS

The operational requirements of the various sub-systems of the SoS are given below:

Information System

- This shopping assistant device shall provide information system that transmits information from database to service system.

Equipment

- The battery and cable shall be installed to guarantee the power of the shopping assistant device and the device shall be low energy cost.
- This shopping assistant device shall be light-weight for end-users to maneuver when switch to hand operating and installed wheels to move easily.
- This device shall be able to carry end-users' bags if they choose the mode.

- This system shall provide correct location positioning and the navigation to end-users.

- Information search functionalities for end-users is also shall be enrolled to find where to buy the products/services they want.

- This device shall provide Chinese to English, Chinese to Japanese, Chinese to Korean, and Chinese to French translation.

- This shall use speaker/sound interaction method to give information and recommendation to end-users.

- Bluetooth, monitor and other hardwares are needed in the shopping assistant device to support the functions the system needs.

Payment system

- Convenient payment way should be supported using credit card and easy to renew for end-users to continue using.

5.2.2 Maintenance Concept for the SoS

The maintenance concepts for the various sub-systems of the SoS are:

Information System

- The shopping assistant device may sometimes have some problems in transmitting information between service system and information system, like navigation errors, language translation mistake and information searching problems. It need the repair and update of the data in the information system.

Equipment

- If the problem is about loss of signal or anything minor in software of device, the employee in mall who get the training about the shopping assistant before could repair it.

- However, if the problem is any more serious like the mechanical structure issues, it need to send device back to our company and let our design team to repair it.

Hardware System

- If the Bluetooth is broken or any other connection problems that make the facility does not function according to the design including navigation, translation and driving, it can be repaired by the design crew of our company.

Payment system

- If the payment system have problems that make end-users can not achieve payment as easy as in their own country just using credit card, there must be some issues that need send back device to our team to repair.

5.2.3 Significant Technical Performance Measures (TPMs)

Information system - The system should transmit information between service system and information system in reasonable timeframe.

Payment system - The device provide end-user very easy and convenient way to pay to use just like they pay in their own country using credit card or other easy method.

Equipment -

- Information transmit is exact and provide the products/services the customers want including information searching and accurate navigation.

- It provide Chinese to English, Chinese to Japanese, Chinese to Korean, and Chinese to French translation.

- WIFI/BLE function work well and guarantee the security during the end-users using it.

Maintenance - The size and weight is as design requirements and could carry bags for end-users to reduce the broken possibility and the electric charge system can provide equipment enough power to work for 8 hours for one time charging.

5.3 Functional Interfaces of SOS
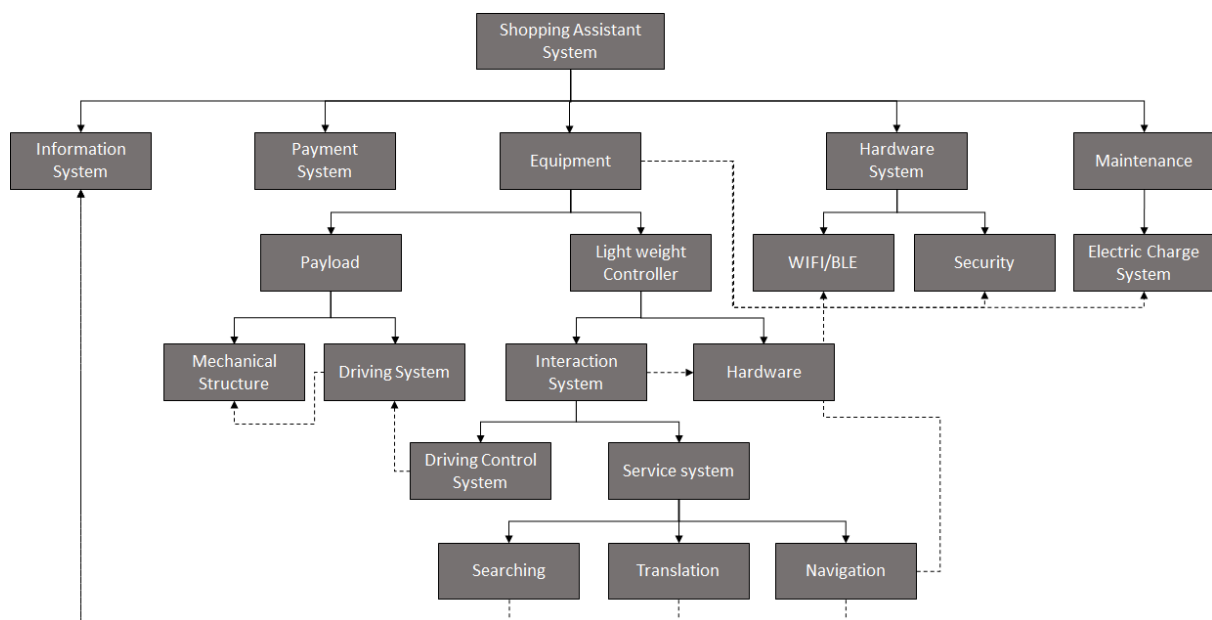
- Interface of electric charge between equipment and electric charge system.

- Interface of data exchage between controller and hardware system (WIFI, BLE, security).
- Interface of information transmit between service system and the information service (database).
- Interface of the manupbility between controller and the driving system in the payload.
- Interface of controlling mechanical structure by the driving system.
- Interface of sending command from driving control system on controller to driving system of payload carrier.

6. Customer, System and Design requirements, and RAS with traceability

6.1 Customer Requirements

ID	Requirement
CR1	The system shall be easy for international end-users to interacted with.
CR2	The system shall be easy to maneuver in the mall.
CR3	The system shall be able to carry shopping bags.
CR4	The system shall provide capability of searching availability, price and user comments of products and services.
CR5	The system shall provide capability of navigation.
CR6	The system shall be cheap to use.
CR7	The system shall be able to be used for single purporse.

6.2 System Requirements

ID	Requirement

SR1	The system shall provide language service for interaction and translation.
SR2	The system shall be able to accept voice input and text input.
SR3	The system shall be easy to pay for use and easy to return.
SR4	The system shall be able be controlled autonomouly and mannually.
SR5	The system shall be lightweight and in appropriate small size.
SR6	The system shall provide space to place certain amount weight shopping bags.
SR7	The system shall provide an application for end-users to search information of products and services in the mall.
SR8	The system shall provide an application for navigating end-users to the store or spot where they want to go based on latest facility information.
SR9	The system shall be able to operated at leaset 12 hours a day.
SR10	The system shall provide detachable parts for different usages.
SR11	The system shall be cost effective.

6.3 Design Requirements

ID	Requirement
DR1	The system shall provide interaction with English, Chinese, German, Japanese and Korean.
DR2	The system shall be able to translate English, German, Japanese and Korean to Chinese and Chinese to English, German, Japanese and Korean.
DR3	The system shall be able to recognise voice input.
DR4	The system shal be able to translate voice input to text.

| DR5	The system shall be able to accept text input.
DR6	The system shall be able to accept credit card payment.
DR7	The system shall be able to accept mobile payment.
DR8	The system shall be able to be returned in any appropriate spot in the mall.
DR9	The system shall be able to display remaining time for using.
DR10	The system shall be able to track the end-user.
DR11	The system shall be able to follow the end-user autonomouly.
DR12	The system shall be able to switch between autonomous control and manually control.
DR13	The system shall weigh no more than 8 pounds in total.
DR14	The system size shall not exceed 10 inches width, 20 inches length and 30 inches height.
DR15	The system payload shall be at least 20 kg.
DR16	The system shall provide a database containing updated information of products, services and facility in the mall.
DR17	The system shall provide a product/service search applicaiton.
DR18	The system shall provide a searching application that will give a recommendation based on end-users' search cretrias.
DR19	The system shall provide an indoor navigation application.
DR20	The system shall provide a long-hour battery to support 12 hours operation.
DR21	The system shall consist of payload system a detachable system for other service.
DR22	The system total cost should not exceed 1000$/per device

6.4 Requirements Allocation Sheet

ID	Requirement	Method
SR1	The system shall provide language service for interaction and translation.	Test, Demostration
SR2	The system shall be able to accept voice input and text input.	Test, Demostration
SR3	The system shall be easy to pay for use and easy to return.	Test, Demostration
SR4	The system shall be able be controlled autonomouly and mannually.	Demostration
SR5	The system shall be lightweight and in appropriate small size.	Analysis
SR6	The system shall provide space to place certain amount weight shopping bags.	Test
SR7	The system shall provide an application for end-users to search information of products and services in the mall.	Test, Demostration
SR8	The system shall provide an application for navigating end-users to the store or spot where they want to go based on latest facility information.	Test, Demostration
SR9	The system shall be able to operated at leaset 12 hours a day.	Test, Analysis
SR10	The system shall provide detachable parts for different usages.	Demostration
SR11	The system shall be cost effective.	Analysis

6.5 Requirement Flow-Down Verification and Integration

ID	Requirement	Requirement Verification	Function
SR1	The system shall provide language service for interaction and translation.	VR1 - It shall be verified by testing that the system has language translation services	Design, Operation and Quality Assurance
SR2	The system shall be able to accept voice input and text input.	VR2- It shall be verified by testing that the system is able to support voice input and text input	Design, Operation and Quality Assurance
SR3	The system shall be easy to pay for use and easy to return.	VR3 - It shall be verified by testing that the system could accept multiple payment methods and to start use and return at any spot in the mall.	Design, Operation and Quality Assurance
SR4	The system shall be able be controlled autonomouly and mannually.	VR4 - It shall be verified by testing that the system support manually control and autonomously control and could easily switch from one to another mode.	Design and Operation
SR5	The system shall be lightweight and in appropriate small size.	VR5 - It shall be verified by inspection that the system is in appropriate weight and size.	Design and Manufacturing
SR6	The system shall provide space to place certain amount weight shopping bags.	VR6 - It shall be verified by inspection that the system is able to support certain amount of weight.	Design, Manufacturing and Quality Assurance

SR7	The system shall provide an application for end-users to search information of products and services in the mall.	VR7 - It shall be verified by testing that the system contains the software application for searching information.	Design, Operation and Qaulity Assurance
SR8	The system shall provide an application for navigating end-users to the store or spot where they want to go based on latest facility information.	VR8 - It shall be verified by testing that the system contains software application for navigation.	Design, Operation and Quality Assurance
SR9	The system shall be able to operated at leaset 12 hours a day.	VR9 - It shall be verified by inspection and testing that the system can be operated continuously for at least 12 hours.	Design, Manufacturing, Operation and Quality Assurance
SR10	The system shall provide detachable parts for different usages.	VR10 - It shall be verified by inspection and testing that the system contains detachable parts and each part works as expected.	Design, Maufacturing, Operation and Quality Assurance
SR11	The system shall be cost effective.	VR11 - It shall be verified by analysis that the system are running at a low cost.	Design, Operation

6.6 Requirement Traceability
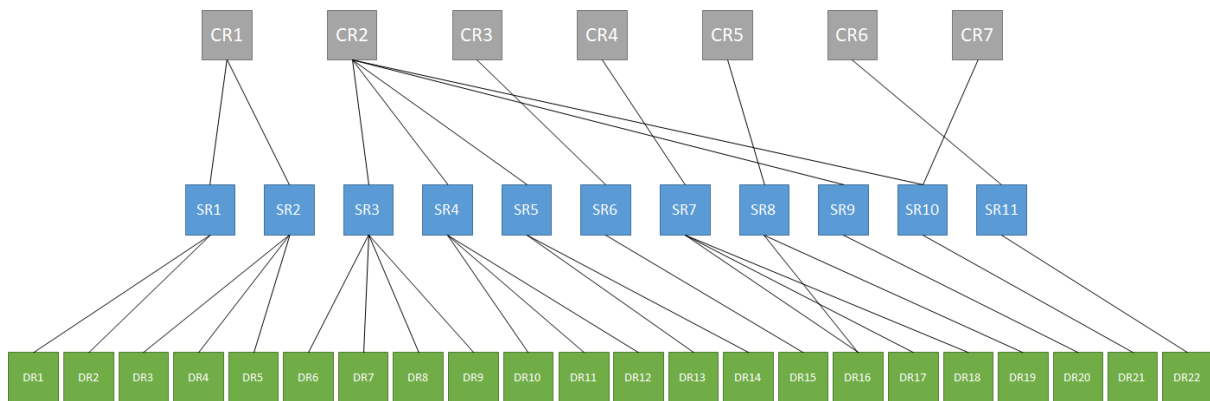
Requirement Traceability Matrix

Customer Requirement	System Requirement	Design Requirement
CR1	SR1	DR1, DR2
CR1	SR2	DR3, DR4, DR5
CR2	SR3	DR6, DR7, DR8, DR9
CR2	SR4	DR10, DR11, DR12
CR2	SR5	DR13, DR14
CR3	SR6	DR15
CR4	SR7	DR16, DR17, DR18
CR5	SR8	DR16, DR19
CR2	SR9	DR20
CR2, CR7	SR10	DR21
CR6	SR11	DR22

7 References

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