

# Problem Analysis

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# 1

When you are going on a trip and have to stay out for one or more nights you usually need to pack some luggage. The way people pack their luggage is not always the same. Some just throw their items randomly into the suitcase, while others put it nicely into the suitcase but without a specific order. Others again have a system regarding which order the items are put into the suitcase. If the bags are not packed in the smartest way possible that means that the consumer have wasted useful space and there fore not fully. Another problem with unorganised packing is that there are no order in the bags and it might require a bigger amount of time for the consumer to find things they are looking for.

## 1.1 Problem

In the modern society, families or groups of friends tend to take on vacation to other countries to relax and enjoy their vacation or explore the world [?].

When going on a vacation or a business trip packing a suitcase is normally needed. You need all you personal items and cloth with you. The length of the stay, the purpose of the trip, and the number of people travelling together effects the weight and size of the luggage. This can be a problem due to the different rules or limits to your luggage when using different means of transformation.

The time spend away affects how much cloth the traveller will need to bring and/or if the traveller will need to wash the cloth while away. A longer stay means of cause that the traveller will need more cloth. This affects the size and weight of the luggage because you will need more or fewer items with you on different trips.

The amount of items to bring also depend on what kind of trip it is and the purpose of the trip. For example if the purpose of the trip is a sport competition, you might need to bring some equipment, you would not normally bring on, for example, a holiday trip. If it is a short business trip all you might need could be a briefcase with your papers and a suit to wear.

The number of people on the trip means more luggage because everyone needs their own personal items, and their own cloth. This can be a problem if the persons have a lot of shared items that has to be spread in different suitcases and need to be found afterwards and it might also effect the total weight of the luggage.

It can be frustrating, when travelling with many and/or heavy suitcases, if you need to carry the luggage far. It can also be hard to manoeuvre if where you are suppose to

walk is a small space or a narrow passage or if simply filled with a lot of people constantly blocking your way.

There can also be a problem with too large or heavy suitcases if you are travelling by plane since this can result in a fee. The size of the fee varies from airline to airline and can be found on the airlines website[?]. The fee has been introduced so the airline bag-handlers do not risk getting injuries by carrying too many, heavy suitcases. To avoid this fee it can be an advantage to pack the suitcases properly and limit the choice of items to bring so the total weight does not exceed the allowed weight.

## Packing

Because of the weight and size restrictions at the airports it can sometimes be difficult to get all the items you want to bring into a small enough suitcase and not exceed the allowed weight. It can sometimes be necessary to acquire more suitcases for the trip or leaving some of the items you wanted to bring. Bringing more luggage means you have to pay more to get the extra luggage with you on the plane. A way you might be able to avoid buying and paying for extra suitcases is to pack the suitcases more compact. This on the other hand increases the bags weight [?]. This should be thought through because too much weight can be unhealthy to carry around if the luggage is packed to heavily.

The increased weight means the bags might exceed the limit for weight and therefore trigger a fee for overweight luggage. It seems people often pack their luggage more compact instead of taking extra bags with them on vacation. Generally people take a lot with them on vacation and they might not have packed their luggage the most effective way [?].

An American website for statistics,[?], shows the amount of fees given in context to luggage that have been registered at the U.S. airlines. Through these statistics it is possible to see, **there are people that exceed the set of limits given by the airline**. A note regarding this source is that the size of the fee is a combination of the different rules and related fees. Therefore the statistics do not give an accurate image of the problem with weight limit, but a more general image of the problems with luggage exceeding the given limits.

The problem with packing luggage is mostly the same if it is by train, car, or flights. But flights is the one transport where it plays the biggest role for the traveller because it has economical consequences. With train and car it is more of less up to the traveller how heavy the luggage is allowed to be but there are restrictions to how big the bags are allowed to be in the train. For train it is 100 x 60 x 30 cm [?], for cars it is the size of the car and number of passages that defines how big the suitcases can be for the journey to be safe.

When going on vacation, and using the car as transportation, the size of the car sets the limit in size of the luggage, since you cannot just pay to get more luggage with you than fits into your car. When packing a car it is important to place the heaviest of the luggage just behind the back seats and evenly spread to the sides. This is to prevent the luggage from gathering momentum during an emergency brake and maybe go through the back seats. Furthermore it is to prevent over steering and thereby evade potential traffic accidents[?].

On a vacation there can be many good experiences and memories. The memories tends to be bound to photos, items and souvenirs and thereby makes it easier to remember. Photos and souvenirs also have a certain value and can be used to fill the home with memories about the past experiences. With this in the mind, it is important to make room for possible souvenirs or other things that simply had to be bought while away.

As earlier mentioned the weight and size of the luggage is a problem before the departure, therefore it will normally also be a problem on the trip home. This means that if a family packs just to the limits and then buy things and souvenirs on their vacation they will get into trouble when packing the luggage for the trip home.

So the general problem is packing the luggage in the most effective way and spreading the weight in the available suitcases, without violating the different rules or limits to size and weight. It can also be a problem to pack the suitcases to the trip home due to the bought souvenirs or other items.

## 1.2 Luggage rules

This section will focus on the general rules regarding luggage when going abroad, whether by plane, train or cruise ship.

### 1.2.1 Charter trips on air planes

Given below is the rules for varies items you could bring on a plane.

#### Checked-in luggage

Check-in luggage is the luggage that will go in the planes cargo hold.

Items not allowed:

- Explosives, including detonators, fuses, grenades, mines and explosive compounds
- Gasses, propane, butane
- Flammable liquids, including petrol, methanol
- Flammable solid matter and reactive, including magnesium, matches, fireworks, flares
- Oxidising and oxidised compounds and organic peroxides, including bleach, auto repair-kits.
- Toxic or contagious compounds, including rat poison, infected blood.
- Radioactive materials, including medical isotopes and isotopes for industrial use
- Corrosive compounds, including quicksilver, car batteries.
- Compounds from combustible systems, which have contained fuel.

Due to the volatile or dangerous nature of the items listed above they have been deemed unsafe and thus not allowed on the plane without explicit permission from the airport.

#### Carry on

Carry on luggage is what the passenger is allowed to bring aboard in the cabin.

Approved items:

- Liquids, perfume, gel and spray – max. 100 ml – equal to one decilitre pr. container
- You are only allow to bring these containers (bottles, cans, tubes and, so on), if they are contained in a transparent plastic bag, which have to be closed (1 litre bag per passenger).

- The bag have to be resealable.
- Past security, wares can be purchased (including spirits, perfume and other liquids). Wares are handed out in sealed bags, these bags may only be opened after the final destination have been reached.
- It is now a requirement that you take off your overcoat, take laptops and other larger electronic devices out of the bag before the security check-in.  
[?]

### 1.2.2 Rules on trains

There are different rules depending on which train company you are using.

The Danish train company, DSB, have very few rules regarding the luggage you are allowed to bring with you.

The only rule is that your luggage need to be able to lie on the luggage rack or under the seat and not be bothering or putting any other person on the train in danger [?].

Another example could be Indian Railways where the luggage is allowed to have different weight depending on which class you are on. They have no other rules regarding luggage [?].

### 1.2.3 Rules on cruise ships

On board a cruise ship the "rules" are not really rules more like guidelines as they encourage the passengers to not exceed the limits. Furthermore the passengers luggage should be kept in their cabin during the trip[?].

### Luggage table

This table displays the summary of the different rules from above.

Type of luggage	Dimension limit	Weight limits
Check-in luggage(Airplane)	158 cm (Height+Width+Depth)	20-23 kg
Extra luggage(Airplane)	158-277 cm (Height+Width+Depth)	20-45 kg
Carry on(Airplane)	Height 50-55 cm + Width 40 cm + Depth 18-25 cm	5-8 kg
Luggage(Train)	100 x 60 x 30 cm	Within reason
Check-in luggage (Cruise)	75 x 50 x 29 cm	30 kg
Hand Luggage (Cruise)	55 x 35 x 25 cm	Within reason

## 1.3 Luggage allowance

Because of the capture and crashing of an air plane into the World Trade Center on the 9th of September 2001, the security of airports have increased dramatically. Some of the hijackers carried knives and box cutters and this led to an immediate restriction of any and all types of sharp objects. The reason the hijackers could get these weapons on board the plane, was lax security around for instance Swiss army knives and blades like a box cutter. Along with stricter rules for items allowed on the plane, a thorough check up of the security personnel hired by the airport have been issued. After the change, airports are no longer allowed to hire their own security personnel due to a lack of discipline and

training and in some cases hiring of personnel with a criminal background.[?]

On the 5th of October 2006 more regulations were introduced to prevent passengers from bringing liquids of too large a quantity on board. **(See luggage rules for a complete list of restricted items)** To construct a bomb a certain amount of "liquid" is required for it to have enough power to be a threat, and studies have showed that 100 millilitre containers stored in a 1 litre bag equals around 500 millilitres of liquids which in turn is not enough to make a bomb that can take down a plane. This restriction covers all types of liquids because the screening points at the security can not distinguish one liquid from another without the security personnel manually checking the various liquids, which would severely slowdown the whole process.[?]

Due to these restrictions packing a bag is not as simple as it used to be. A lot of items are no longer allowed and thus it can be difficult to know what is allowed and what is not. As the restriction covers all sorts of liquids packing a simple toilet bag is time consuming.

## 1.4 Solutions on the market

This chapter are used to research the marked and thereby get a image of what solutions there already exists on the market. Through the research it is also possible to determine, how the existing solution helps the user with the stated problem. By looking at existing solutions it can be used to determine what features that would be needed in a more problem oriented solution.

The amount of lists and guides on the market is huge. These lists and guides offer help and provide tips for packing for travelling. Some of these lists and guides have been developed into applications that are available for the customer to use.

An application or in short app, is a program that fulfil different kind of services for the user. Apps are used in the web browser, computer, smart phone, and tablets. The term app is generally mentioned in context to smart phones and tablets.

There also exist programs, that have integrated algorithms to handle optimization of the packing, on the market that can be used. First a look into these lists and guides and the more advanced solution thereafter.

### App - Packing Pro

Packing pro is an app developed for the Iphone and Ipad that offers templates for check lists to the customer. Iphone is a smart phone and the brand is owned by Apple. Packing Pro uses a touch interface which means that the user by using the finger can navigate around. This is possible because Iphone and Ipad support touch navigation.

Packing pro is designed with a panel in the bottom of the screen that allows the user to navigate through the menus. Packing Pro provides the user with a help menu that contains information on how to use the app. There is also a menu in which the user can change the color theme of the app. On figure: ?? can be an example of how a check list could look like.



Figure 1.1: Picture of 2 of Packing Pros menus from [?]

These templates are designed to different purposes regarding the customer, gender, type of trip, and purpose of the trip. The customer can then load the wanted template for the purpose. The user also have the possibility to create their own lists by adding things that should be remembered for the trip by them self. The user also have possibility to select an existing list and delete the objects that were found irrelevant by the user. The user can then check object on the lists off as it get packed. Packing Pro is a management tool that helps the customer get an overview of all the things to remember. As the name implies(pro) the app have to be bought before it can be used [?].

Packing Pro works as check list and help the user remember what to pack, but it does not preform any organization of luggages content itself. So Packing Pro itself does not solve the described problem but helps the user remembering what to pack. So a feature to use from this program is the check list function that gives the user an overview of things to pack. A function that would not be needed is the compatible with Iphone/Ipad operating system. It would be nice if the program made work cross platforms but it is still not required to solve the problem.

## App - Checkmark Packlist

Checkmark Packlist is an free app for the smart phones running the Android system. Checkmark Packlist offers different templates for check lists that the customer can use. One of these templates is the list for packing for a trip. That way the customer can select and use this template for remembering what they will need to pack for the trip. Checkmark Packlist uses touch to navigated in the program. This means that the customer with their fingers can navigated through the check list and check off things that have been packed.



Figure 1.2: Picture of the Checkmark Packlist in action from [?]

Checkmark Packlist does not provide customization tool that let the customer add more categories to the check list. This is only a featured provided in the paid version of Checkmark Packlist [?].

This app does not provide a solid solution to the found problem but helps the user remembering what there should be packed for trip. This check list feature give a guiding effect and this is a useful feature and can be used in the product design to solve the state problem. A feature to consider is the mobility by designing the program for hand held devices.

### Online check/tip list

The online check list works as a reminder when packing luggage. It also give tips and tricks that could be considered when packing for the trip. There exists a lot of different websites offering this service for free. Some are posted by an organization and others by a person on a forum. This means that all electronic devices as computers, tablets, and smart phones that have access to the Internet can open the website address. An example of this kind of website is the following source [?]. This website offers a list of 10 tips that can be helpful for the customer when they are packing for a trip. On figure: ?? these 10 tip can be seen. The site does not help with the actual packing, instead it helps with the planing of materials that the user might want to have on the trip. The website is designed with a menu left that let the user navigate through the different content of the website.

- 1. Plan ahead.** Know what type of weather to expect and what your activities might be, then pack the right clothes for the climate and your events.
  - 2. Pack less.** Expect to wear each clothing item more than once. Choose versatile pieces that can be worn in different combinations so you don't get bored.
  - 3. Pack a "go-anywhere" wardrobe.** This means taking clothes that blend in with the local population and provide safety from those who target tourists. For instance: modest necklines for women; long pants or skirts; shirts with a collar and sleeves; and comfortable shoes (see below).
  - 4. Pack easy-care clothes that you love.** To ensure that you will look and feel great on your trip, choose clothes from your closet that still appear fresh at the end of a long day. If things wrinkle at home, they will wrinkle while traveling.
  - 5. Take comfortable shoes.** You will not have a good time if your feet hurt. Three pairs of shoes are the maximum for most trips: one to wear and two to pack. Include good-looking and comfortable walking shoes or sandals, more dressed up shoes for dinner and social events, and sport or athletic shoes.
  - 6 Choose the right bag for the trip.** Structured bags with wheels protect the contents and offer independence in airports, while bags without wheels and without structure are generally easier to squish into small places, such as in the trunk of a car.
  - 7. Know the current airline luggage rules.** To avoid additional fees and confusion at the airport, understand how many pieces of luggage may be checked, plus the maximum dimensions and allowable weight for each bag. Call your airline or check [www.smartpacking.com](http://www.smartpacking.com) for the latest information.
  - 8. Pack smart.** Use SMART PACKING tips and tricks to fit everything into your luggage in the most space efficient way, and to provide easy visibility during security checks. For example, group small items in see-through containers or self-sealing plastic bags. Take less or pack two bags to speed the security check process as an overpacked bag takes longer to check manually and is more difficult to repack.
  - 9. Travel light.** Two smaller bags are usually easier to manage than one larger bag. Wheels are an asset on smooth terrain, but you must still be able to carry your bag on rough streets and up steep flights of stairs.
  - 10. Take a lock.** Today's airport security requires luggage to be unlocked, but pack a lock so you can secure your bag when you leave your room. However, leave valuables at home, as there is really no safe place for them when traveling.
- The moral to the story is if you follow these simple guidelines, you will have the freedom to go everywhere -- independently and comfortably.

Figure 1.3: Screen shot of [?] where they have posted 10 tips

The online check/tip list in itself does not give the customer a solution to the packing problem. The websites instead help the customer planing the trip and thereby no the actual problem. The type of check/tip list used on [?] does not apply as a useful feature that could be used in the final program. Instead it would more be focus on helping the user with the packing.

## The e-Commerce shipping calculator

The e-Commerce shipping calculator is an advanced program that helps the customer packing large containers and calculates the price of the shipment. By typing the size, weight, location, and destination of the items that should be shipped, the program can calculate what the prize is going to be and generates a 3D(3 dimensional) model of the container where the given items are placed in the best possible way so there are a minimum of wasted space. On their website [?] they offer a demo(demonstration) of their program. Their demo runs through the web browser and thereby should be accessible from computers connected to the internet. The demo is design to have the containers dimension variables and weight limit as input fields. Under the container is there are list of item where each item can have different dimensions and weights. To right of these field is the 3d model placed that will be generated. The customer have to type all known data in and press "Calculate Rates" and the program will then form a 3d model, this can be seen on figure: ??.



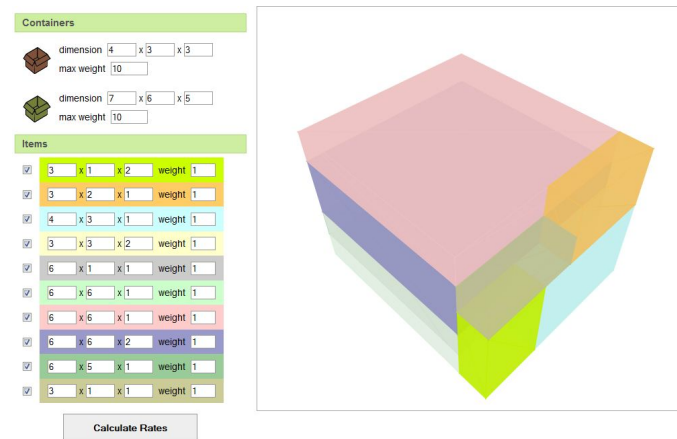


Figure 1.4: Screen shot of the program running taken from [?]

This product have a number of useful features that can be used in the final product. This solution can take items dimensions and weight and calculate the most optimal placement in the container. This can be related to packing your luggage for a trip. So a feature to have in the final product is to calculate somewhat most effective way to pack the users luggage. Another useful feature is that this solution also shows it to the user. So the final product most inform the user in similar or another way how the luggage should be pack.

## Recapitulation

This section main object is to look at the wanted features and recap them in a table. Packing Pro and Checkmark Packlist is similar in the way that they helps the user. They both provide the user with a sort of check list that can be check off and thereby help the customer remember what have not been packed yet. One of the difference is that Packing Pro have a price while Checkmark Packlist is free. But this difference means that Packing Pro allows the user to edit the check list while that are not possible in Checkmark Packlist. These two apps do not help the user arrange the luggage content or take in consideration of size and weight of it. Thereby is two apps do not help people with the packing itself but more what should be remembered for the trip. The online check/tip list provide the user with advices for the trip and what to pack. Advices are great to get a general idea of what to take pack but it still does not give a more effective way to pack. The e-Commerce shipping calculator is the one solution with the most wanted features. One of the strong feature that can be used is the ability to calculate the most effective that a container should be packed. A important side note is that the intentions is not to pack bags but the feature can be related to packing content of a bag.

Included in product	Solutions			
		App - Packing / Packing Pro	App - Checkmark Packlist	Online check/tip list
Guide the user		x	x	x
Distribute weight				x
Distribute space				x
On the road		x	x	x
Baggage rules				
Where in the suitcase				x
Packing list		x	x	x

Table 1.1: Table for the different products on the market compared to features

Table: ?? consists of features down the y-akse and exiting solution on the market out the x-akse. The crosses indicates when the particular product has the particular feature. The purpose of the table is to give a overview of the products compared to features that was found essential to the problem. Table: ?? shows that none of the exiting solution does not take rules regarding baggage. It also shows that there are a lot of help regarding what to bring but when it comes to packing it is only one of the selected solution that had this feature.

### 1.4.1 Thesis Statement

In this section a thesis statement will be formulated which will be used to develop a method to this problem and to get a more precise problem to work with. The method is used to try and solve the problem stated in the thesis statement.

- Is it possible to develop a program that helps the customer through the progress of packing one or more suitcases the most effective way?

The meaning of this thesis statement is to research and develop a program that in some way could handle the problem and all the calculation that lies in the problem. But the consumer also plays a role in the problem. Therefore the consumer must also be taken into account when it is being developed. The reason for this is to make the program as user friendly as possible.

### Sub Statement

The sub statements have been made to help find a solution to the thesis statement. These sub statements describe some of the steps that need to be made in order to find the solution for the thesis statement.

- **How can it be checked that the weight in the suitcases are evenly distributed and it does not exceed the allowed weight or the volume in the bag?**

The program will need to handle and solve calculations with weight and volume. Through these algorithms the program should find the most effective solution for the given data. It will also have to check that the solutions weight does not exceed the given limits or the volume of the luggage.

- **Which functions are needed to get the program to compute the most effective way to fit the items into the suitcases?**

Some functions are needed for the program to find the best solution. The functions will use an algorithm for optimising and thereby the program will fulfil its purpose.

- **How should the program communicate with the user and inform where the items are placed, and tell how much space is left?**

The program will have to be developed and tested so the customer can use the program to its full extent. Therefore it is important not to use advanced technical language or unexplained abbreviations.

- **How can the program be developed so it takes the length of the journey into account, and enable the user to update the program on the go?**

The program should also be developed so it is possible for the user to update the programs database while on vacation thereby get a packing order for the new content of the bags.

From this thesis statement there will be developed a list of requirements for the program, which it will need, to solve the given problem and be user friendly. The system requirements can be seen on page ??

## 1.5 Method

This project structure will be based on Aalborg PBL (problem based learning). The Aalborg PBL is a method whereby the learning process lies in the work with a problem and try to develop a solution for the given problem. The Aalborg PBL method also trains the students ability to work together in a project group and give them tools to handle the processes that goes with working in a group.

The first stage of the project is the problem analysis, which purpose is to find and document that there is a problem to begin with. From the problem analysis a thesis statement is formed and is used to produce a list of product requirements. The requirements are then use to design and develop a product that should solve the problem stated in the thesis statement. The program are then tested on the target group of the problem. The testing leads to a conclusion of the project. This is the main focus of the project, when using the Aalborg PBL. This project form is used because it finds and document a problem and then through the work with the problem gives an estimated solution to the problem.

To document the problem, a lot of information is needed. The information is found through different sources such as; books, article, websites, etc. When using information found through the internet or other sources it is important to evaluate the used sources. This is done to filter out unreliable sources and thereby achieve a better and more trustworthy project. This process of evaluation is also known as source criticism and are general used when using others materials as documentation. Therefore it is also a relevant method to use when using sources in the project work.

# Design 2

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## 2.1 Specification Requirements

The program has some features, which are essential for the program to work, these are catalogued as "targeted features". The other features, the program does not necessarily need to work, is catalogued as "Nice to have" features.

### 2.1.1 Targeted Features

These are the features that the program will have.

**Guide the user:** The program will have a little "readme" file, or other form of guide, that will tell the customer how to use the program.

**Distribute weight:** The program must be able to distribute weight of items evenly in each individual suitcase and if needed spread out in multiple suitcases.

**Distribute space:** The program also needs to distribute the items by space. The whole idea of the program, is that it should be able to tell the user how to pack the suitcase, and be able to tell if there is enough space for eventual souvenirs. Lastly it should inform the user how much space, if any, is left.

**Account for the trips length:** If a long trip is planned, the program must be able to account for more souvenirs.

**On the road:** The program will be able to tell you, while you are on the trip, if there is enough space for a souvenirs, if you input the dimensions and weight of that item.

**Baggage rules:** The program will need to know basic baggage rules. For example the luggage must not weigh too much, and it must be below certain dimensions.

**Where in the suitcase:** When the user asks the program if an item will fit in the suitcase, the program will show exactly where in the suitcase the item will fit.

**Solid/liquid/bendable shapes:** The program will also take in account that items might be bendable, and therefore fit in other ways than solid items. For instance a T-shirt can be folded in many ways and thus can be considered a liquid form as it can fit almost everywhere.

**Packing list:** To make it easier for the user to know what will be packed an editable lists will be included depending on the type of trip.

### 2.1.2 Nice to Have Features

**Type of trip** Depending on the nature of the trip different packing lists will be necessary because each trip might require different items.

**Number of people** Usually a trip is done with more then one person, so more suitcases might be available to distribute items between.

# Theory 3

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## 3.1 Bin Packing Complexity

The Bin Packing Problem is NP-hard ???. This means that the problem is at least as hard as an existing NP-complete problem. NP-complete means, in simple terms, that every combination must be examined, and then the best combination must be chosen. An example is the Traveling Salesman Problem (TSP), where a list of cities and distances between the cities is given. The problem is then to find the shortest route to visit all cities, and to end at the starting point.

## 3.2 Bin packing problem

Bin packing problems is a combinatorial NP-hard problem. The problem consists of fitting objects of different sizes into bins of identical sizes ???. This could for example be fitting various packages into shipping containers. There are various approaches to solve the bin packing problem. Bin packing problem is focusing on bins instead of suitcases but they are basically the same only major different is probably size. Some of the popular methods will be described in the following section.

### First fit (FF)

The first fit algorithm creates a list of the objects needed to be fitted into bins. It then runs through the list, checking if an item can fit in each bin: If it cannot fit in the first bin, it will check if it can fit in the second bin and so on. If it does not fit in any bins, it opens a new bin, and fits the object there.

### Best fit (BF)

The best fit algorithm is the same as the first fit algorithm, except that before an object is packed, the algorithm checks each open bin, where the object fit. It will then place the object in the bin which will have the least space left when the object is packed.

### Last fit (LF)

This algorithm packs the object in the last open bin which has room for it.

### Worst fit (WF)

The algorithm checks all the bins, and packs the object in the bin which has most empty space.

**Almost worst fit (AWF)**

Similar to the worst fit algorithm, but the almost worst fit algorithm packs the object in the second-emptiest bin.

**First fit decreasing(FFD)**

The above algorithms are very ineffective because the biggest objects might be placed at the end of the list, and thus be packed in the end, where it is more effective to first pack these large objects. The first fit decreasing algorithm takes this into account and sorts the list before attempting to pack the items. This way the biggest items will be packed first.

**Best fit decreasing(BFD)**

Again this is the same as the best fit algorithm, but with the list being sorted before attempting to pack the objects.

**Round up**

It seems that it is more effective to sort the lists before attempting to pack objects into bins. This way bigger objects are packed first, and the smaller objects can then be fitted around the bigger objects. However in some situations it is necessary to use unsorted lists. For example in a factory with continuous production, it is never possible to have the complete list of objects, and thus never possible to sort the list.