

# Product Architecture

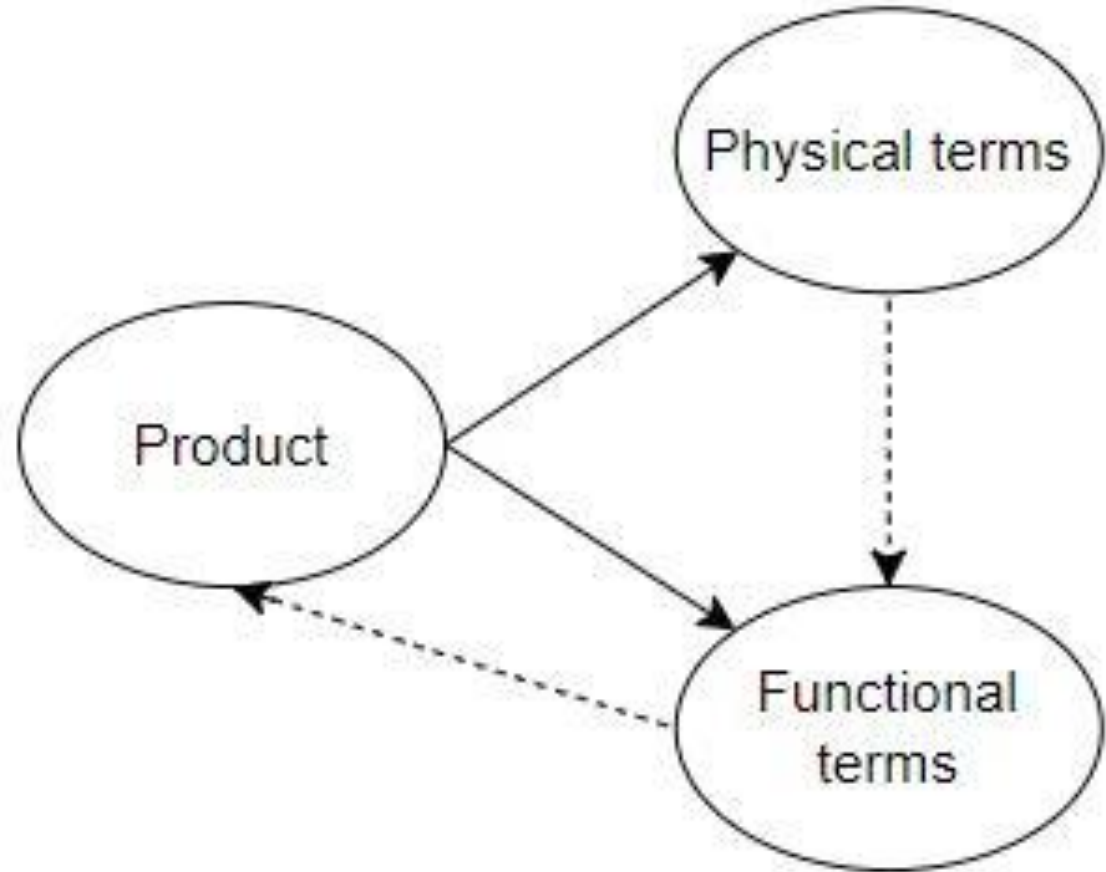
Group 5

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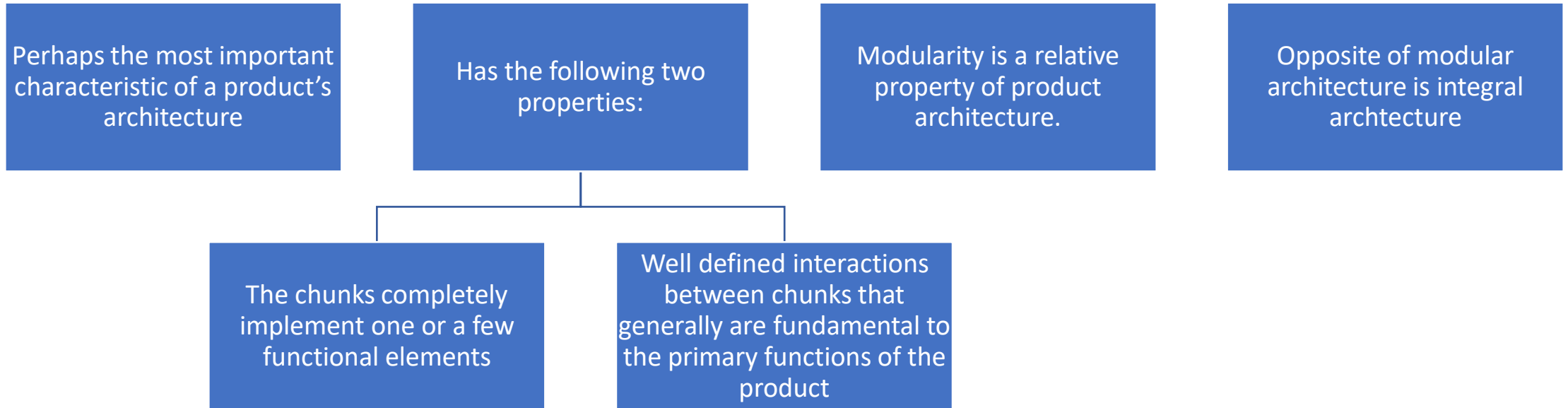
# Product

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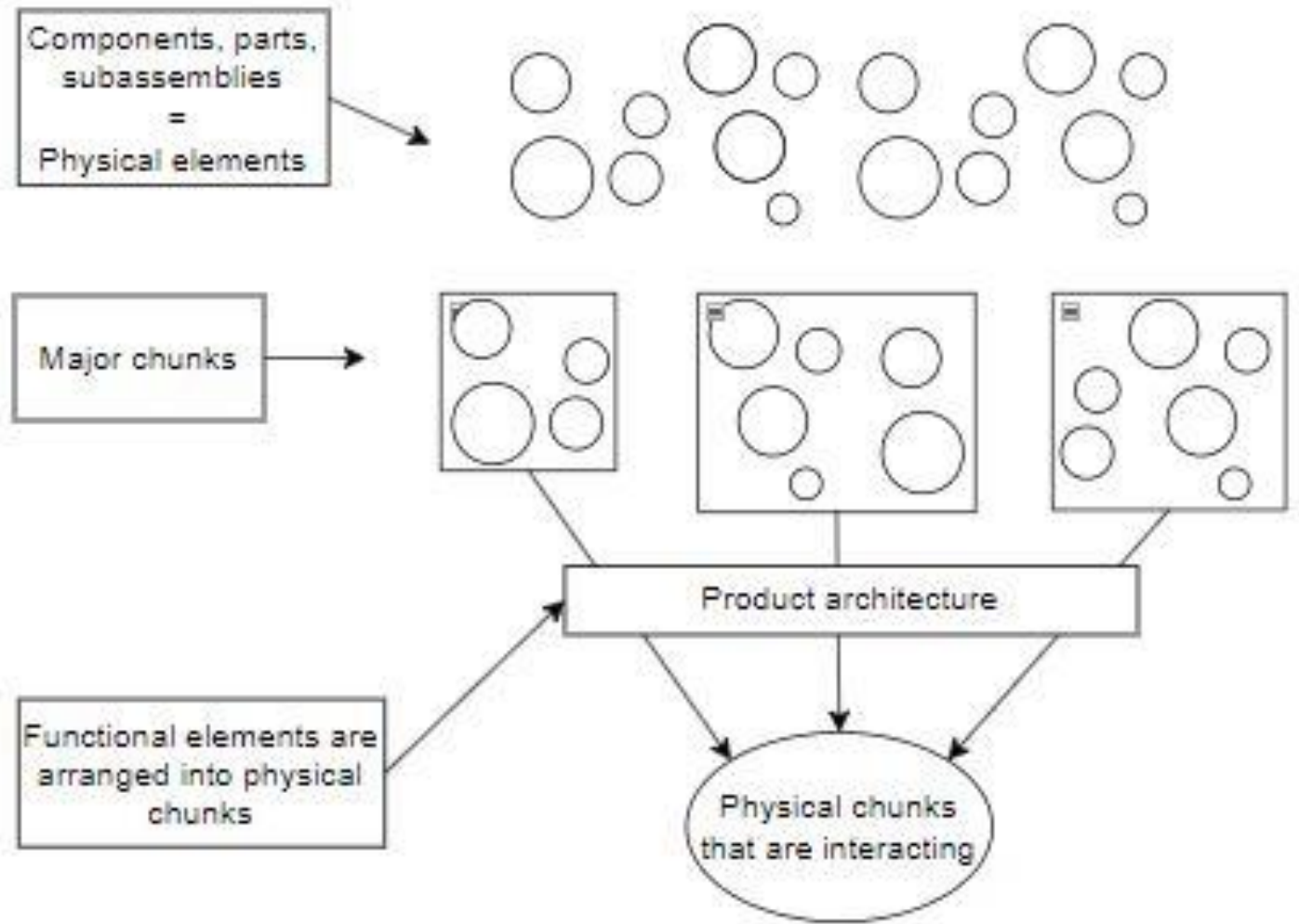
*First, the concept of the product must be understood in order to understand what product architecture means.*



# Product Architecture : Modularity



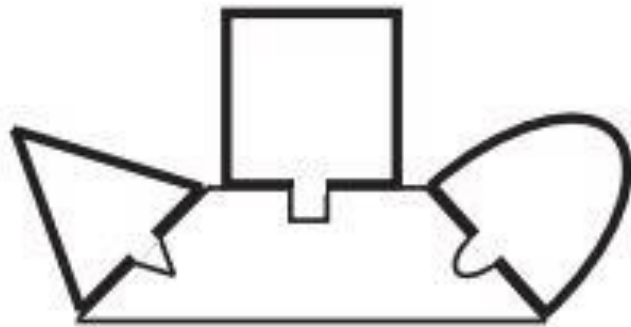
# Product Architecture : Meaning



# Types of Modularity

## *Slot vs. Bus vs. Sectional*

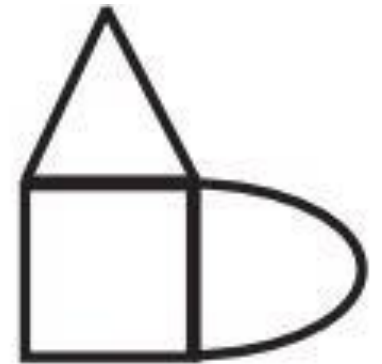
The differences between these types come from how the chunks interact with each other and the how the chunks are connected to other chunks



Slot-Modular  
Architecture



Bus-Modular  
Architecture



Sectional-Modular  
Architecture



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## Implications of the Architecture

Using the previously mentioned architectures, the components of the product can be changed for the following reasons:

- Upgrades
- Add-ons
- Adaptation
- Wear
- Consumption
- Flexibility in use
- Reusage

Minimal change to achieve functional change



# Component Standardization & Product Variety

- Standardization → Using the same standardized components
- Variety → Using the same components to create a *range* of products







Picture sources: Specialized and Shimano



Ultimate CF SL - 2899 €



Ultimate CF SLX - 7299 €



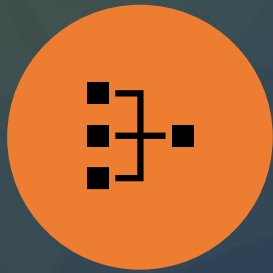
Ultimate CFR 10 399 €

# Manufacturability

Same frame + Different components = Many products

→ Easier to manufacture one frame and buy different components

# Establishing the architecture through four steps



CREATE A SCHEMATIC OF  
THE PRODUCT



CLUSTER THE ELEMENTS OF  
THE SCHEMATIC



CREATE A ROUGH  
GEOMETRIC LAYOUT



IDENTIFY THE  
FUNDAMENTAL AND  
INCIDENTAL INTERACTIONS

A dark blue bicycle with a brown seat and handlebars, shown in profile against a light gray background. The bicycle features a classic diamond frame, a chain drive, and two wheels with many spokes. The text "Step 1: Creating the schematic" is overlaid in white on the center of the image.

# Step 1: Creating the schematic

Picture source: Brilliant Bicycle Co.

# Identifying the functional elements of the product

What is absolutely required?

("The bike has to be able to move and steer... so it will need handlebars and wheels")

But...

It is possible (and sometimes favourable) to define the need as a "functional component"

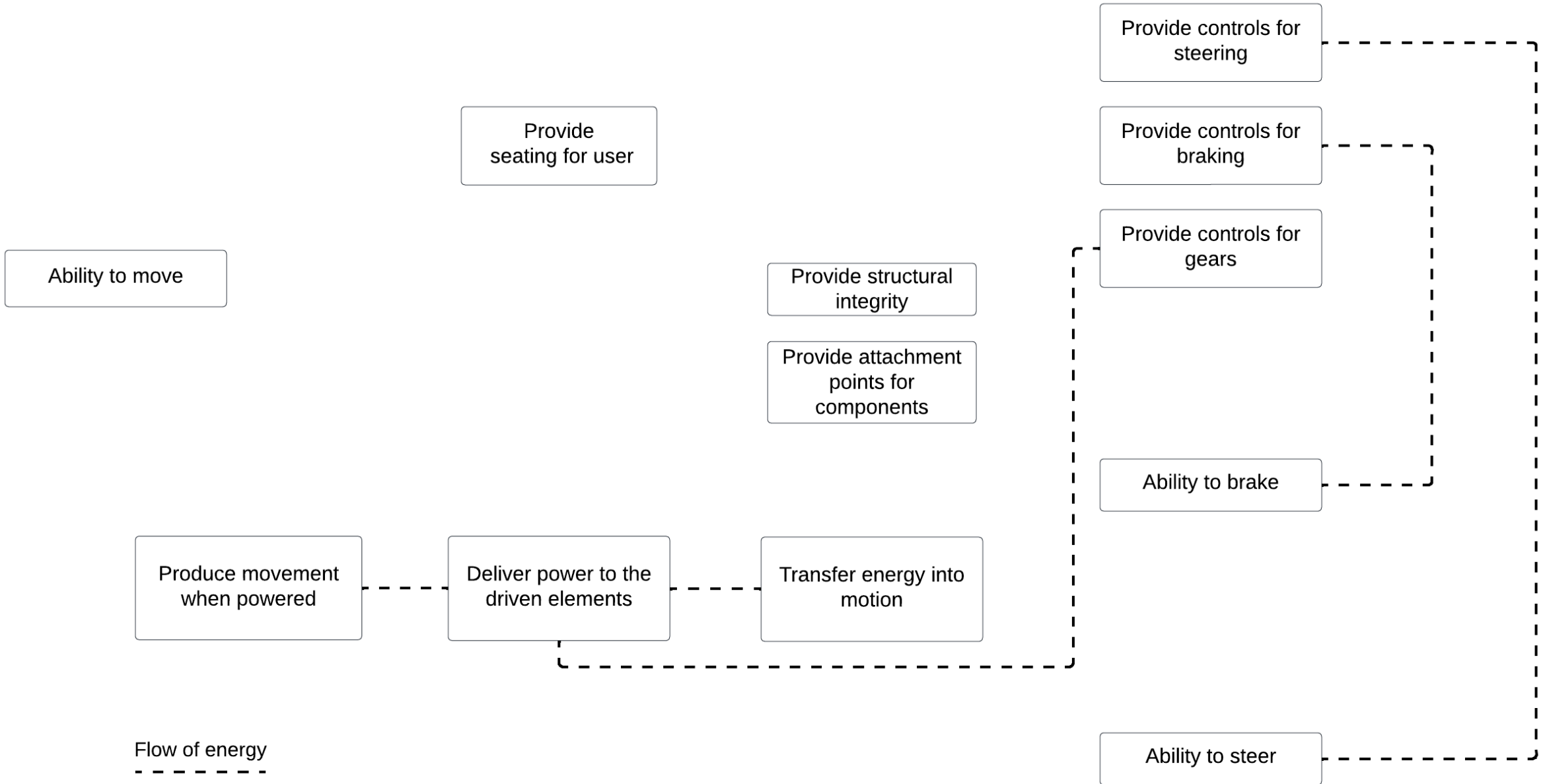
(Eg. "It must have handlebars" -> "It must be steerable")

If it is already certain that the product will have a certain part, it can be listed as a "critical component"

(Eg. "The bike will have a frame")

There are several different approaches and solutions to creating a schematic, and as a general rule, the team should choose the schematic that least constrains their future architectural choices.

"The schematic should reflect the team's best understanding of the state of the product, but it does not have to contain every imaginable detail..." (Ulrich & Eppinger, 2016)





## Step 2: Clustering the elements of the schematic

Picture source: TBS Bike Parts



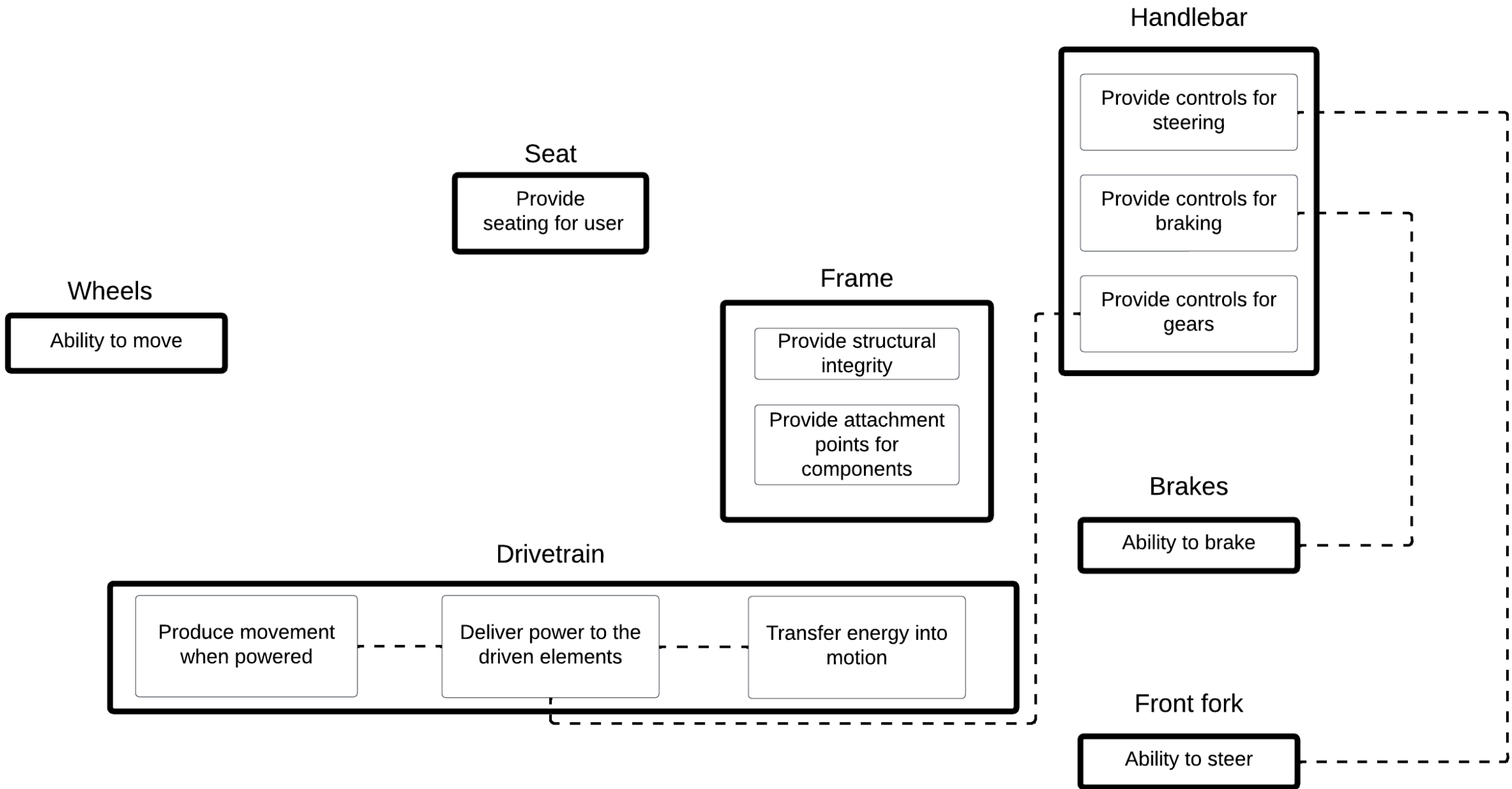
# Clustering can be done in different ways

Things to consider:

Single chunk should contain functional elements that are somehow related to each other (eg. "provides structural integrity" and "provides attachment points to other components" could be accomplished by the same chunk)

In our example, drivetrain (sprockets, chains, derailleurs...) could be supplied by a single vendor -> it might be beneficial to chunk together all of the elements related to drivetrain

Clustering should be done in a way that a single chunk could be assigned to a single design team



Flow of energy

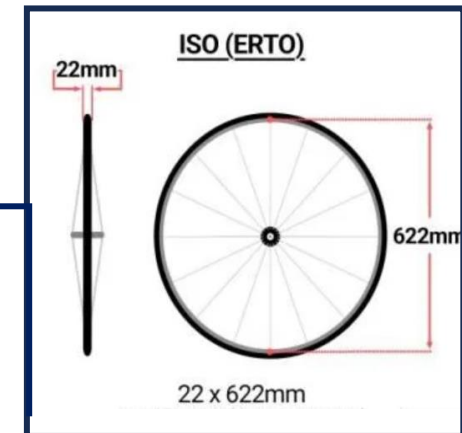
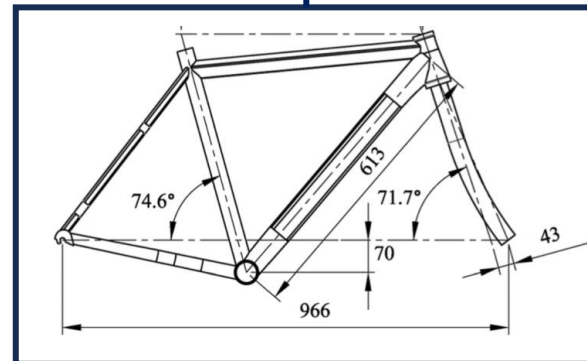
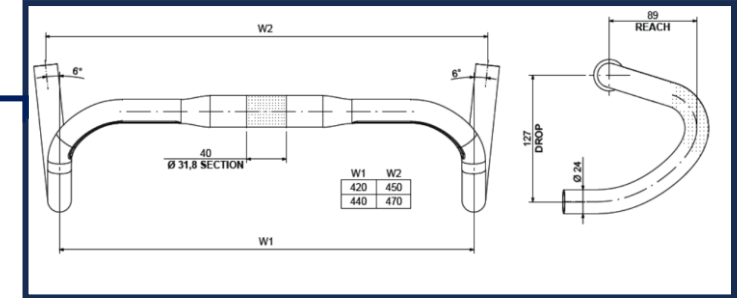
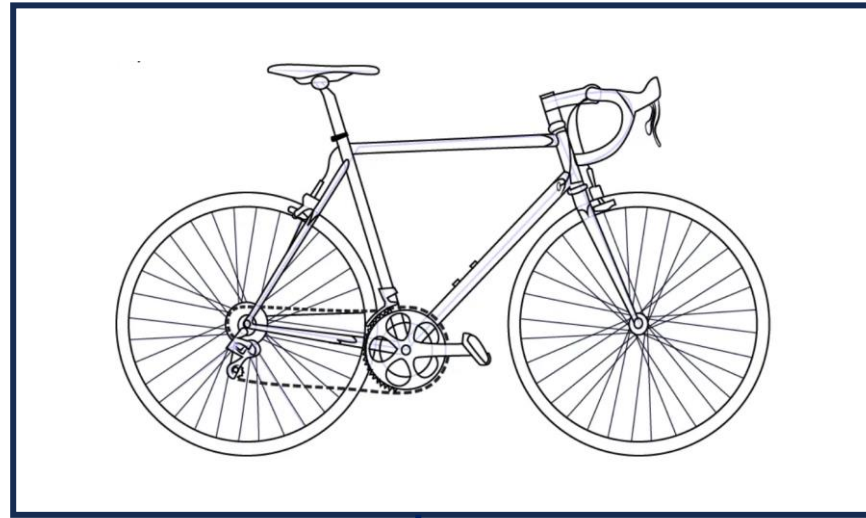


3. Create a rough  
geometric layout

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Geometric layout allows and forces the team to think the interfaces, dimensions and trade-offs between the different chunks of the product.

More relaxed or aerodynamic?  
Road or gravel?



# Different layout types

## Sketching:

- Visualizing different ideas
- Size, dimensions
- Common agreement



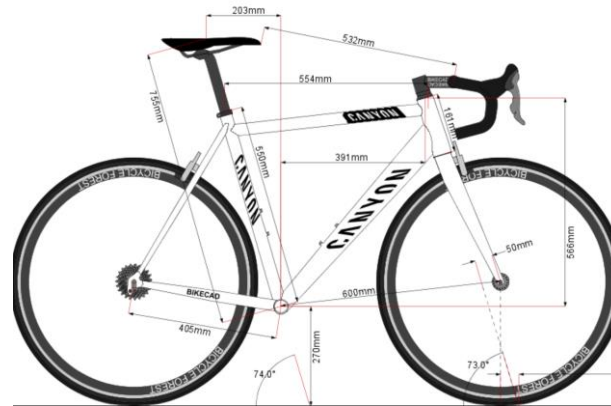
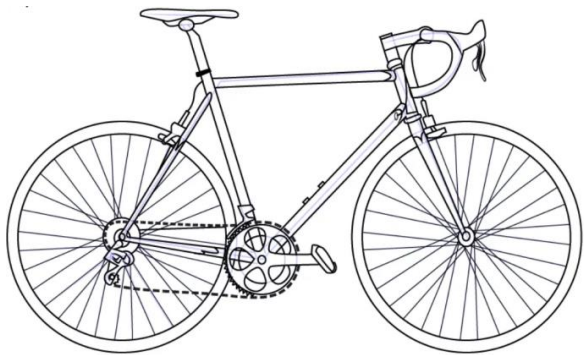
## Computer models

- More detailed visualization
- Simulations
- Manufacturability



## Physical product

- Prototype allows testing
- Quality check
- Needed changes before production.



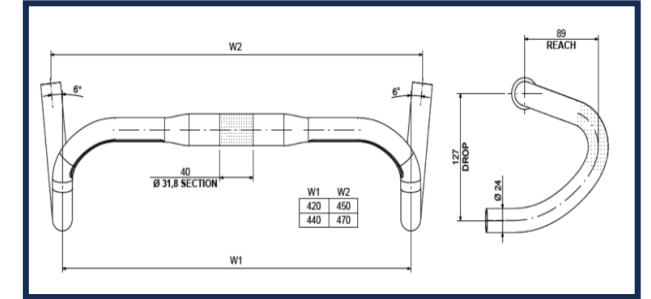
4. Identify the fundamental and incidental interactions

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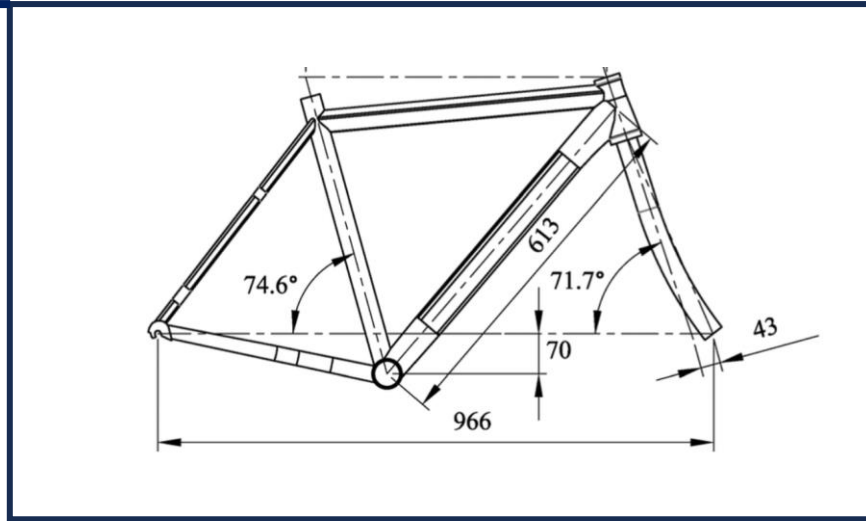
# Fundamental and incidental interactions



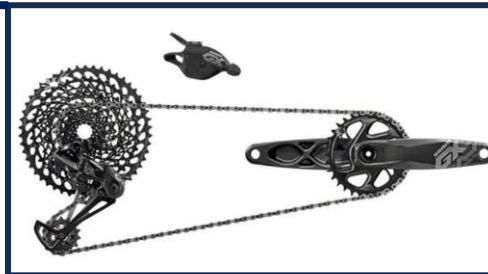
Unneeded vibration

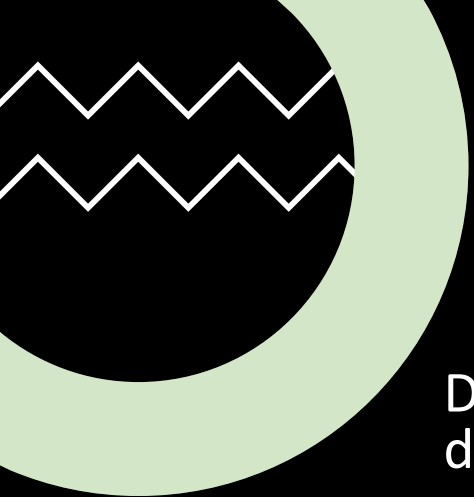


Unneeded vibration  
Planned force and movement for steering



Planned power transmission





# Delayed Differentiation

Delaying finishing products to meet demand and avoid surplus supply

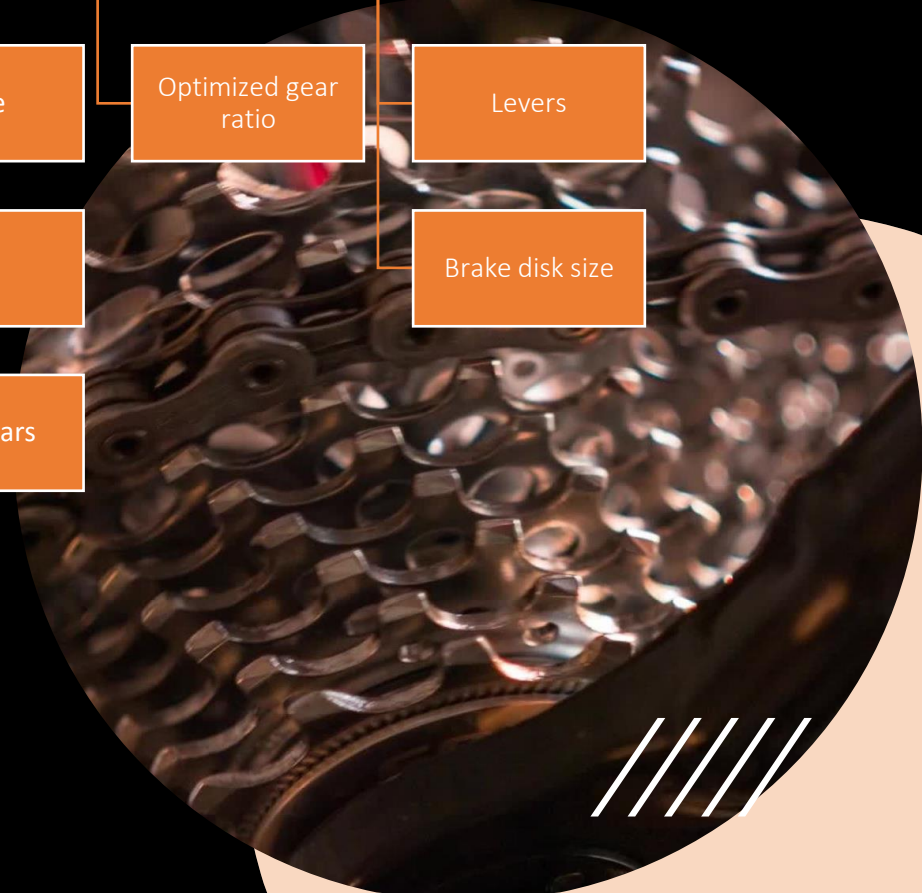
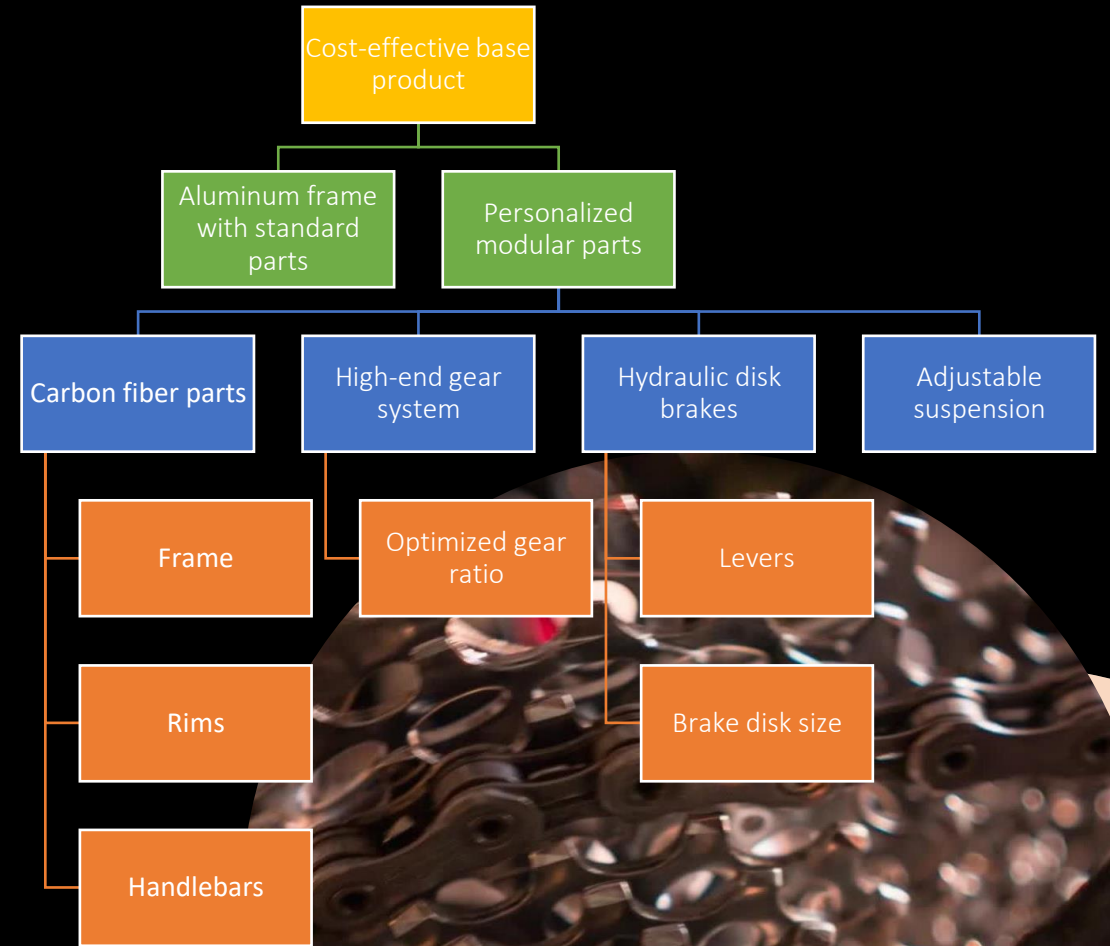
- Via bicycle example again – Same base product with different components for less or more expensive variants

Cost-effective base product

- Works well for the target group

Personalized modular parts according to customers' needs and preferences

- High-end gear systems
- Carbon fiber rims and other light-weight parts







Delayed differentiation provides substantial reductions in the costs of production

Demand for each version of the product is unpredictable

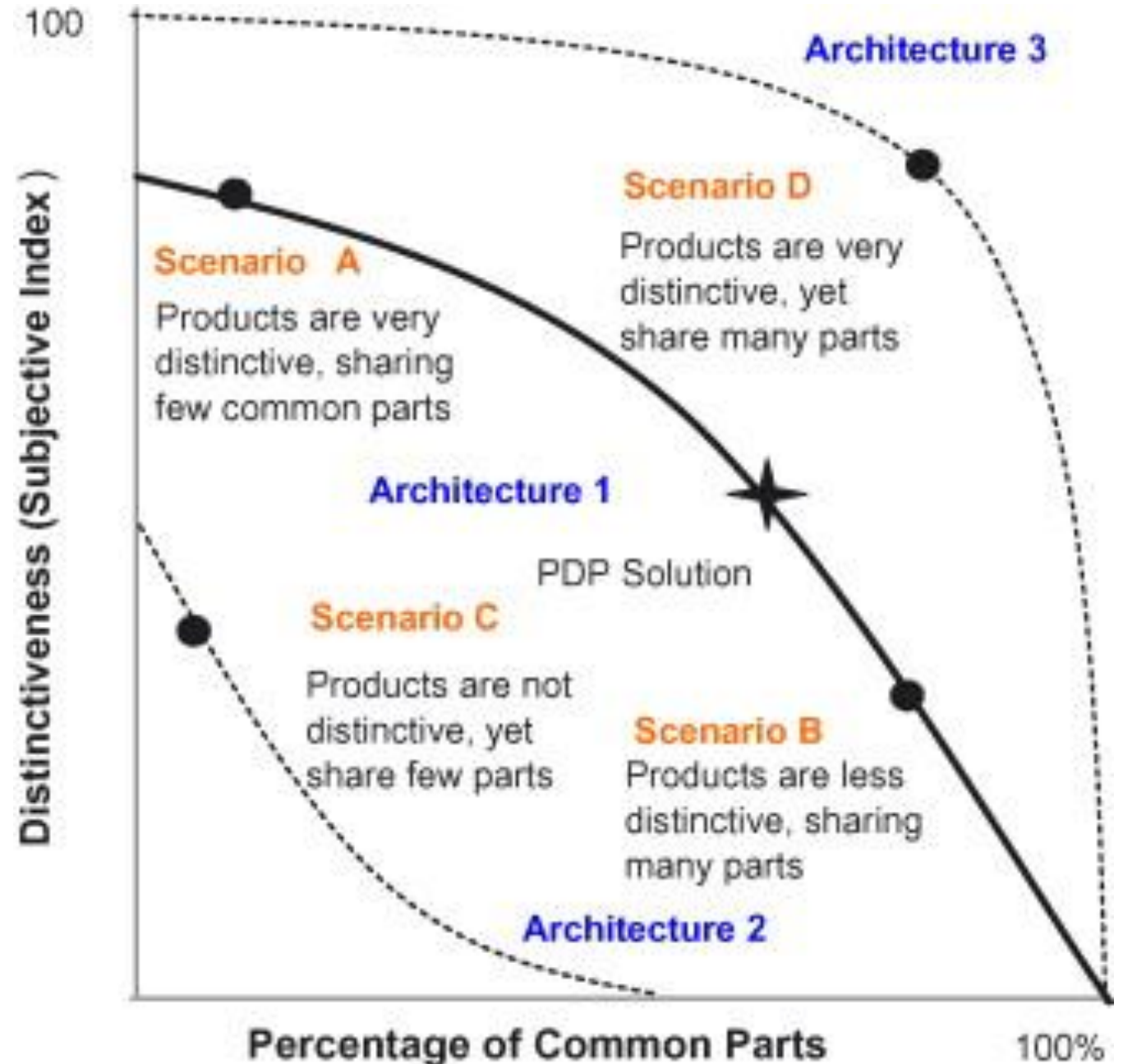
- Requires inventory management

Demand for basic components is more predictable (The base product)

- Differentiating components should be assembled late in the supply chain
  - Easier to handle inventories
  - Production costs decrease

# Platform Planning

- The market can be divided into different customer groups
- One product for everyone -> too many compromises
- Entirely different products for each group -> too expensive
- Solution: A common platform (architecture) with differentiating components
- Must find a balance between distinctiveness and commonality



# Differentiation plan

- How are the products different from a consumer point of view?
- ***Differentiating attributes*** selected from aspects important to the consumers
- Unconstrained differentiation plan -> Exact match of customer preferences -> Too expensive

Differentiating attributes	"Youth"	"Mainstream"	"Premium"
<b>Frame type</b>	Compact	<b>Adult</b>	<b>Adult</b>
<b>Style</b>	Youth mainstream	Mainstream	High-end
<b>Wheel size</b>	26"	<b>28"</b>	<b>28"</b>
<b>Drivetrain</b>	<b>7-speed hub gear</b>	<b>7-speed hub gear</b>	11-speed derailleur
<b>Brakes</b>	<b>Rim brakes</b>	<b>Rim brakes</b>	Disk brakes

## Commonality plan

- What aspects of the products are physically the same?
- Must be done in collaboration with the differentiation plan

Chunks	No of types	"Youth"	"Mainstream"	"Premium"
Frame	2	XS26-series	XS28-series	XS28-series
Seat	1	Trekking version	Trekking version	Trekking version
Wheels	3	26" all terrain -type	28" all terrain -type	28" all terrain -type
Front fork	3	XS26 rim version	XS28 rim version	XS28 disc version
Drivetrain	2	7-speed hub gear	7-speed hub gear	11-speed derailleur
Brakes	2	"Tektro" rim brakes	"Tektro" rim brakes	"Shimano" disc brakes

# Managing the trade-offs

- ***Cost-revenue estimates:***
  - How much does further differentiation benefit sales?
  - Do the increased sales justify the higher production cost?
- ***Iteration:***
  - Make several iterations based on approximate information rather than agonizing on details during fewer iterations
- ***Architectural limitations:***
  - Different product platforms cause different limitations for differentiation and commonality
  - Irresolvable conflicts call for a change in product architecture

# Issues

- Most issues in product architecture arise when the chunks are connected or secondary systems are implemented in design.
- How all the different options are taken into account when planning the common parts?
  - How all the different options are connected to the frame?
- How the secondary systems connect to the other chunks?
  - Brake lines of the bicycle connect to the frame even though they don't have any function in the frame.
- How different chunks fit together?

# How to avoid the issues

- The most important tool for avoiding the issues is planning.
- The interfaces in different chunks need to be planned and common protocols set in the beginning of the project.
- Can some secondary systems be left out or implemented into primary chunks.
- Who should design the secondary systems, one individual or team, or should the team be gathered from the teams designing the primary chunks to get different perspectives.

# Picture sources

- <https://www.bikelockwiki.com/bike-wheel-sizes/>
- <https://bike.bikegremlin.com/946/road-bar-geometry/>
- <https://www.bikecad.ca/1420985135627>
- <https://www.drawingtutorials101.com/how-to-draw-a-bike>
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- <https://www.cgtrader.com/3d-models/vehicle/bicycle/detailed-not-textured-bike-seat>