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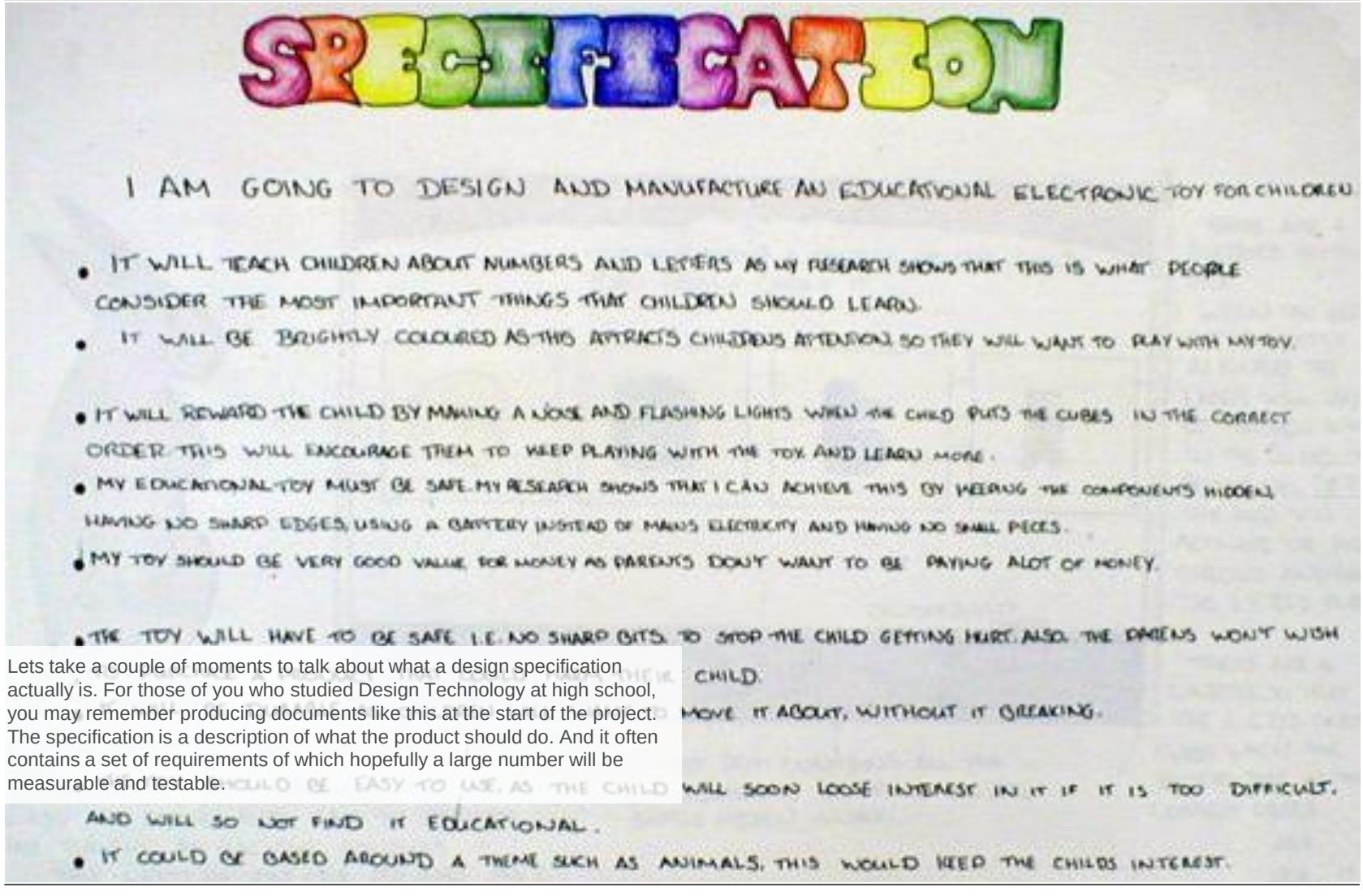
This is an annotated version of presentation given at the Institute of Ergonomics and Human factors conference in April 2015.
The accompanying paper provides more detail.

Specifications for innovation

How do we develop innovative products and services within pragmatic project constraints

Thank you all for coming along, this presentation is titled specifications for innovation. And it's genesis really starts with a question – "how do we develop interactive products and services with pragmatic project constraints".

The paper seeks to address a very practical concern of practitioners, of which I am one, by addressing it through the eyes of a retired academic.



Lets take a couple of moments to talk about what a design specification actually is. For those of you who studied Design Technology at high school, you may remember producing documents like this at the start of the project. The specification is a description of what the product should do. And it often contains a set of requirements of which hopefully a large number will be measurable and testable.

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Product specification

A designer must make sure products meet the product specification. The product specification should be directly influenced by the analysis of research. This will ensure quality of design and that the end product is fit for purpose.

A specification is a statement that tells the designer exactly what the product has to do and what the design requirements are. A specification should include:

- product function
- overall dimensions
- materials
- an outline of the appearance of the product
- user requirements
- details of the source of power (if needed)
- anthropometrics and ergonomics
- possible production levels
- legal requirements
- environmental considerations and requirements

Anthropometrics is the study of the sizes of people in relation to products. For example, chairs used in schools need to be suitable for the average size of pupils in the schools.

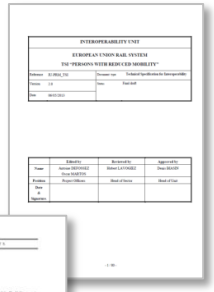
Ergonomics is the relationship between people and the products which they use. Anthropometric data is used to help design products to meet ergonomic needs. Ergonomics also considers the force a person can apply, for example when using a tin opener, or the pedals of a car.

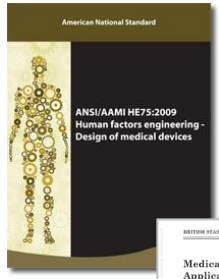
On the web

Now to check my memory of GCSEs was correct I double checked on the BBC website and sure enough, it says that the specification should describe aspects such as the function, dimensions, materials and user requirements.
I was also very excited to see that the first two areas explained were Anthropometrics and ergonomics.

The underlying principle remains true as one moves through from GCSE DT to commercial design. And specifications tend to get written in one form or another for all products, regardless if it is a toothbrush or a train that we are developing.

How do we populate the HF bit?



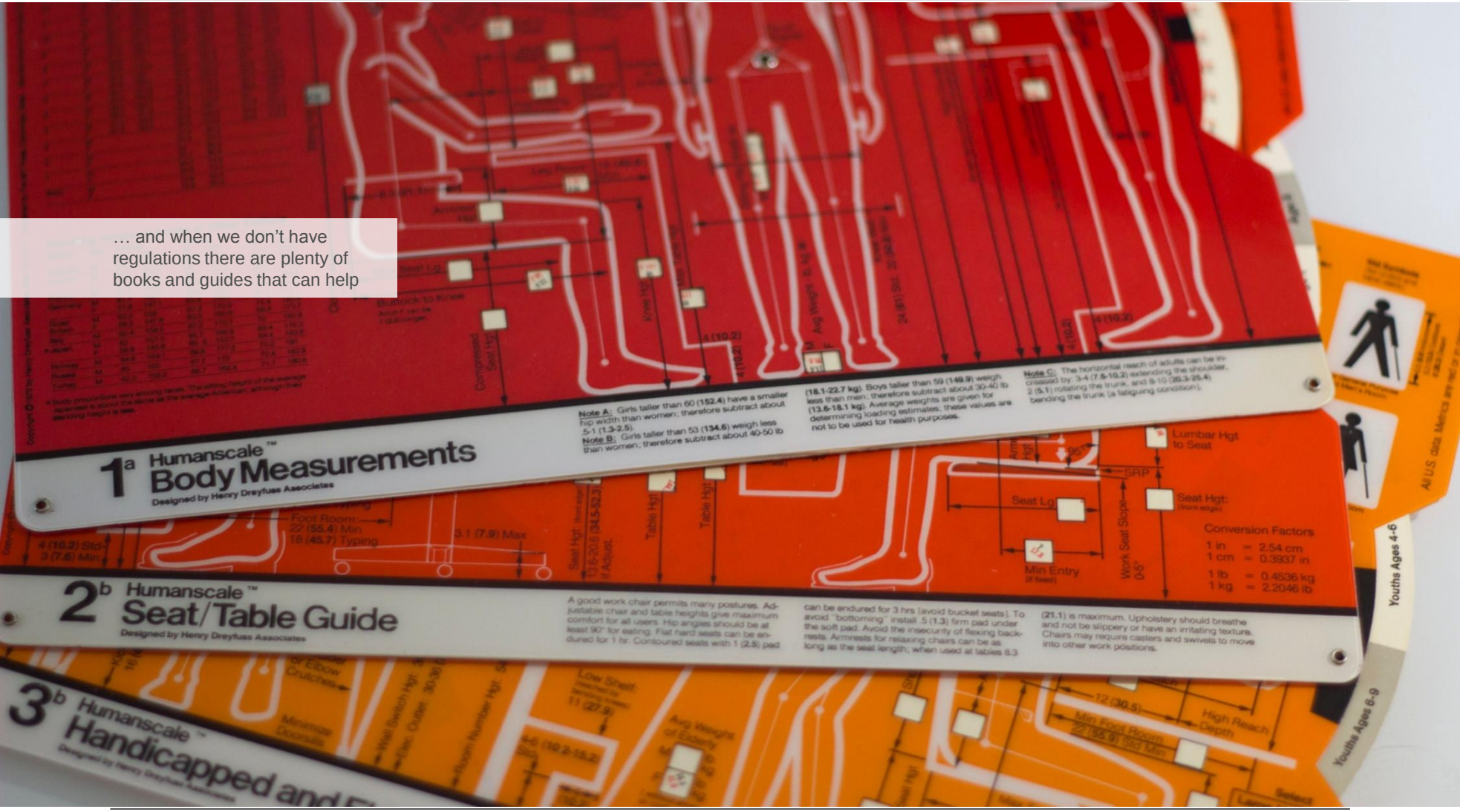


Regulations are a great starting point for many industries, they tell us lots of things like, how high buttons should be, what acceptable actuation forces are etc.

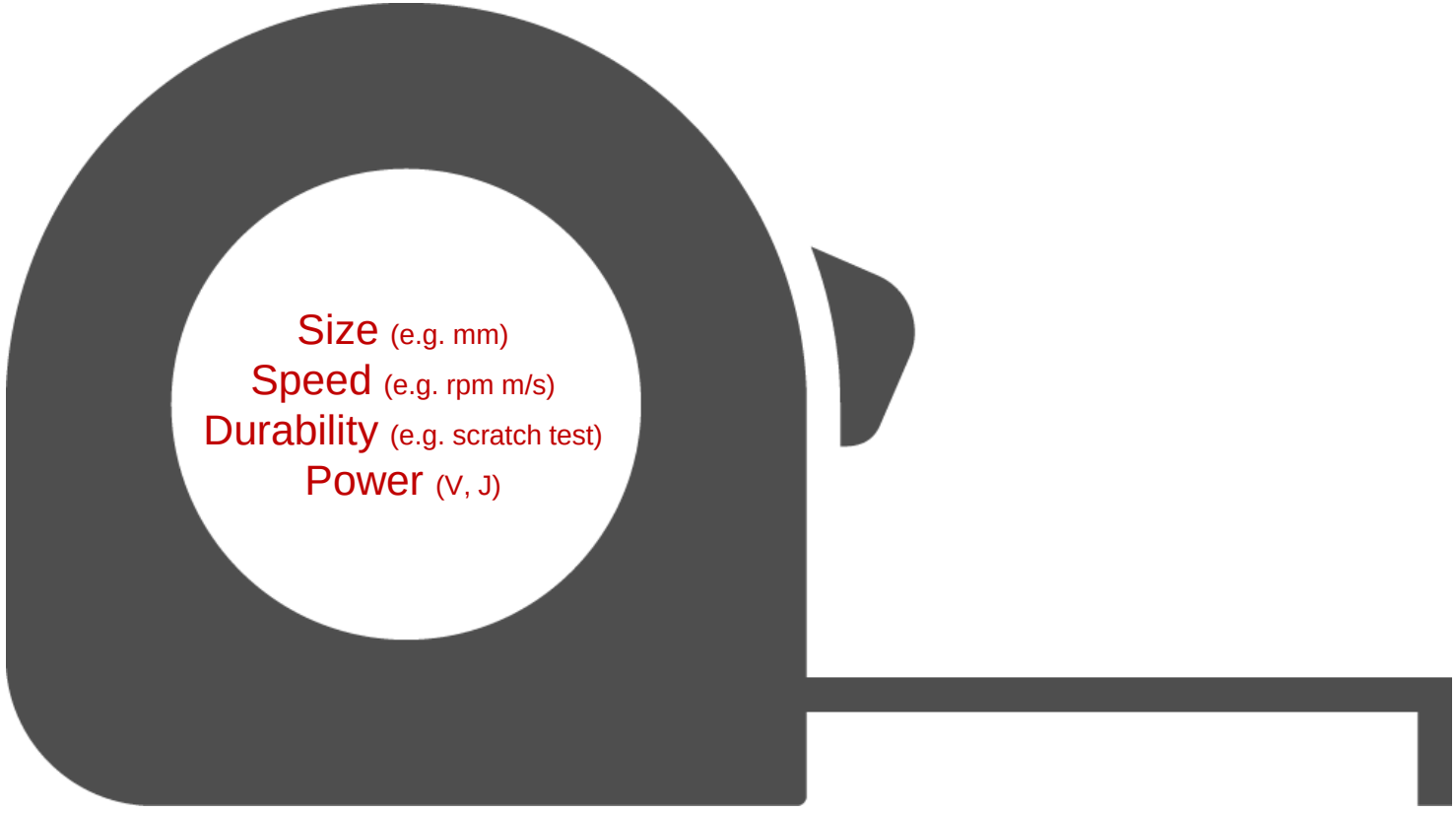
Regulations

?

… and when we don't have regulations there are plenty of books and guides that can help



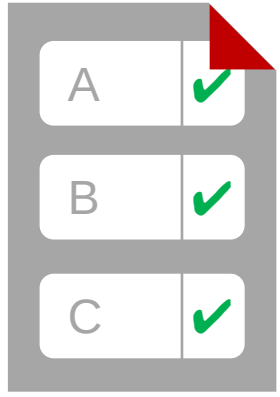
Engineers love them, Particularly when they are measurable and testable

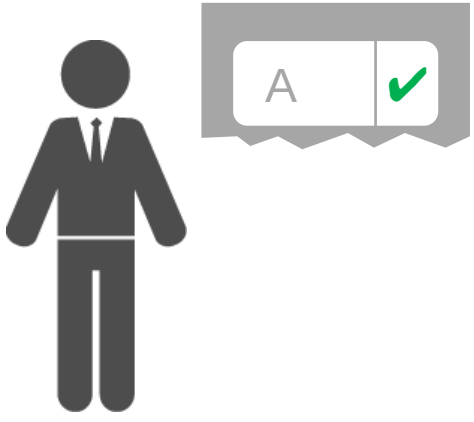


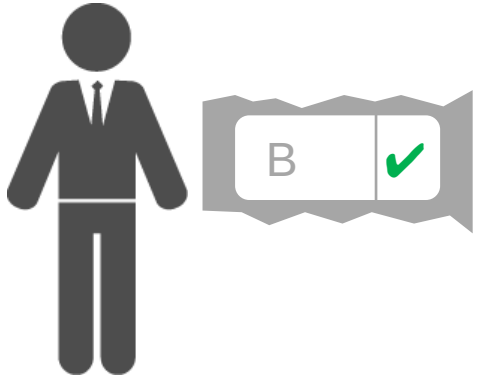
The role of the specification in teams

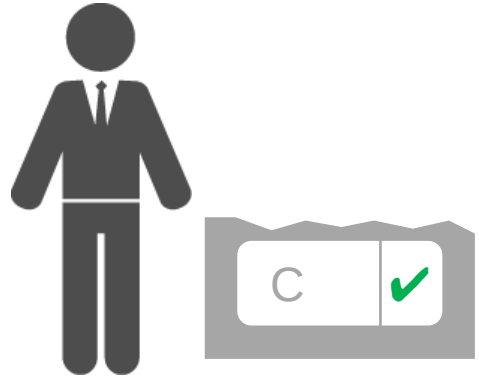
One of the great advantages of a classical specification is that it can be split into parts and distributed across the development team, which may be across a number of organisations

And this generally works well if the assumption is true that if you meet all of the requirements you develop a great product

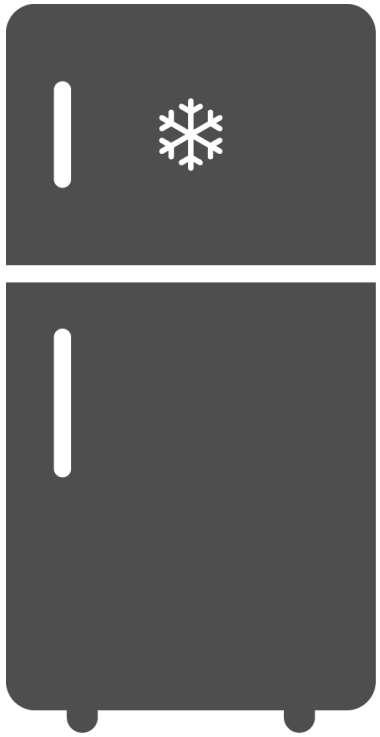


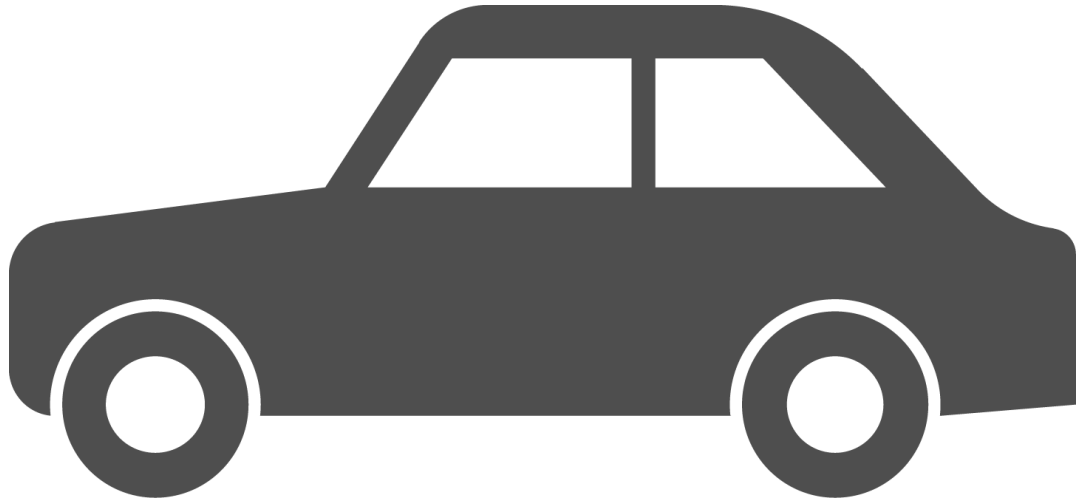






It tends to work very well in companies that produce variants of the same product, for example white goods or automobiles



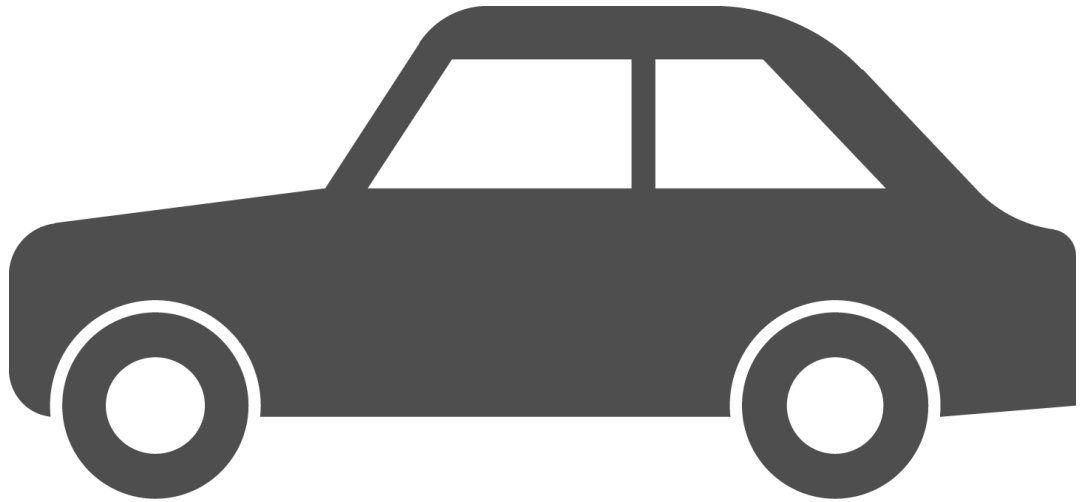


In many cases a project can start with a template specification by effectively filling in the blanks

Shall carry
X people

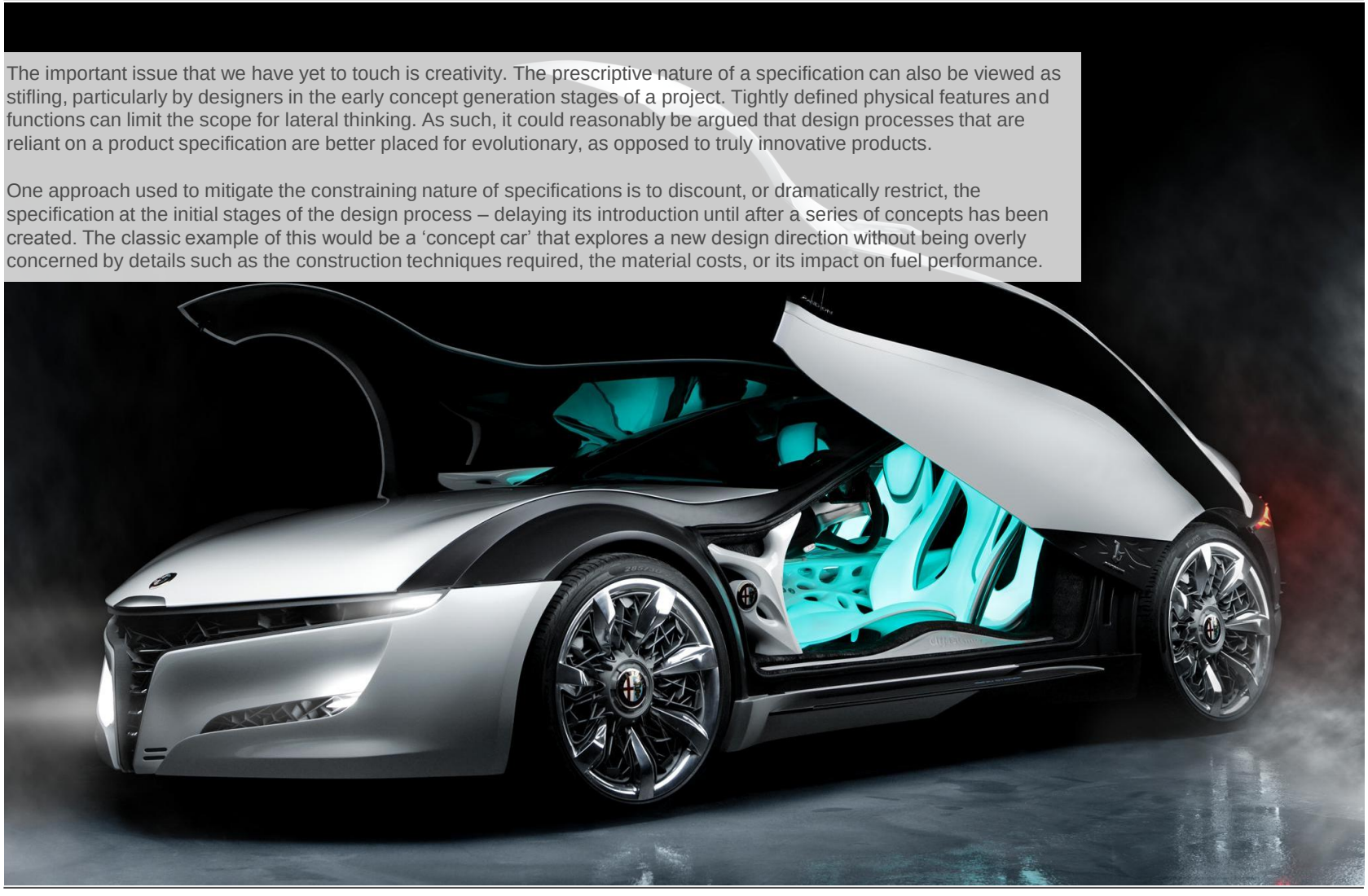
Shall have Y litres of luggage space

Shall achieve Z mpg (urban)



The important issue that we have yet to touch is creativity. The prescriptive nature of a specification can also be viewed as stifling, particularly by designers in the early concept generation stages of a project. Tightly defined physical features and functions can limit the scope for lateral thinking. As such, it could reasonably be argued that design processes that are reliant on a product specification are better placed for evolutionary, as opposed to truly innovative products.

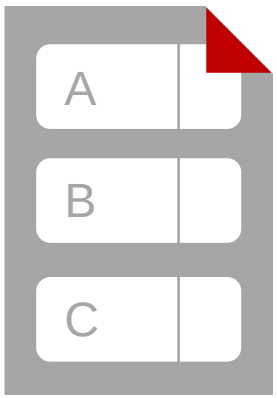
One approach used to mitigate the constraining nature of specifications is to discount, or dramatically restrict, the specification at the initial stages of the design process – delaying its introduction until after a series of concepts has been created. The classic example of this would be a ‘concept car’ that explores a new design direction without being overly concerned by details such as the construction techniques required, the material costs, or its impact on fuel performance.

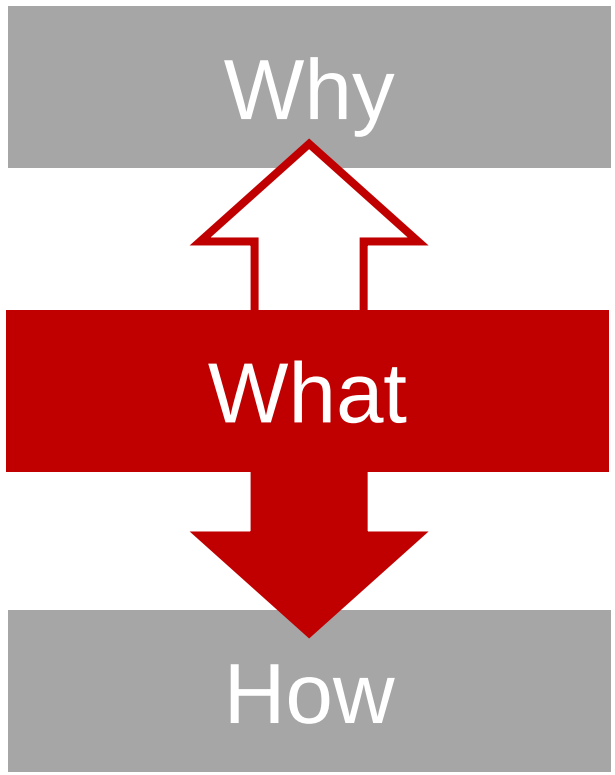


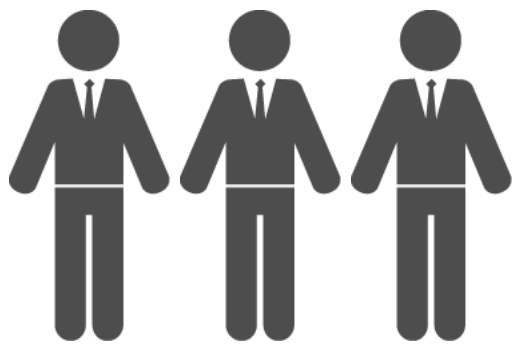
In essence, a specification a description of what a product does

And it down to the engineering and design to use this description to determine how the product should function

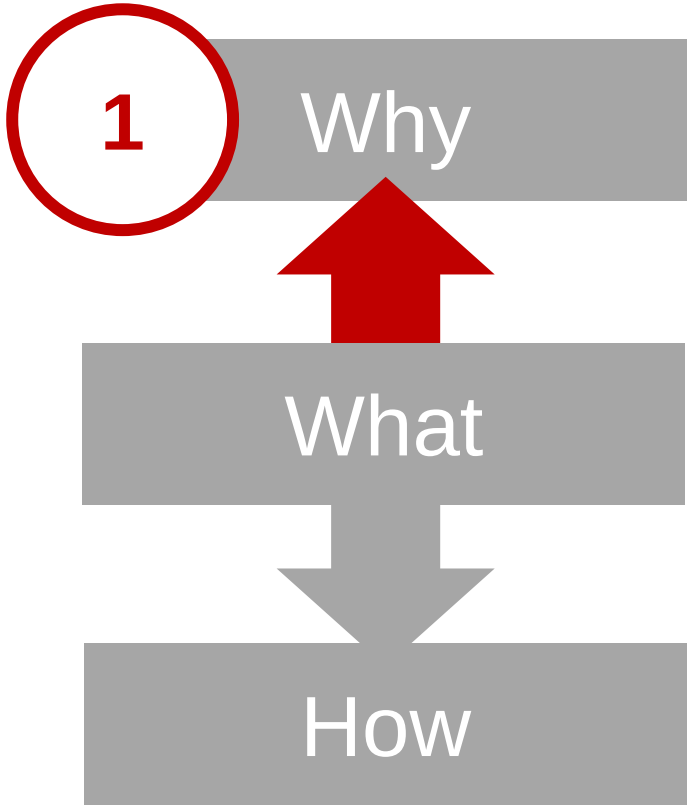
What is typically missing though is a description of why the product needs to do these things

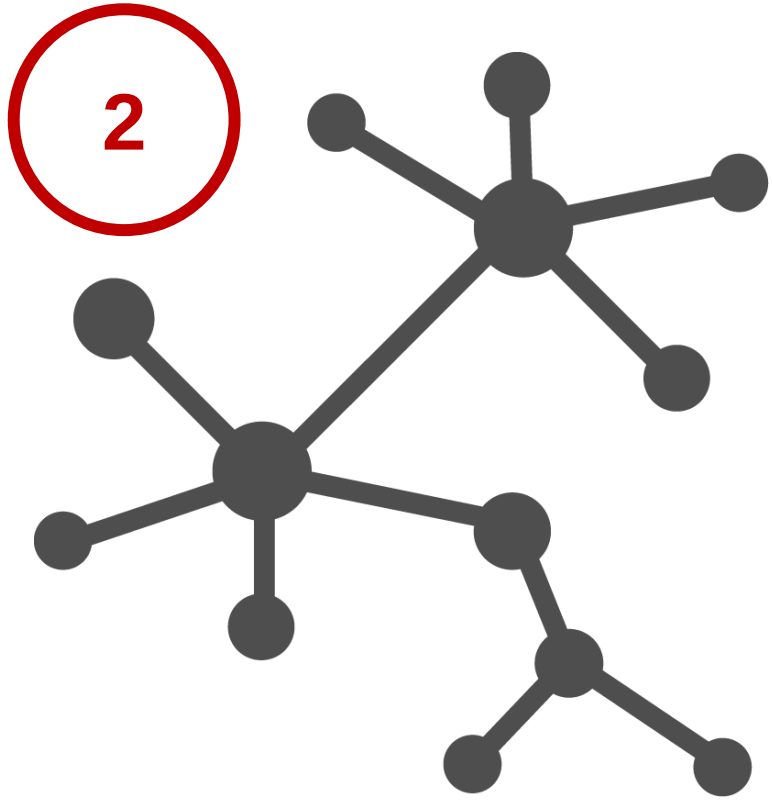






A second failing is that the inter-relationships between each of the system components is rarely explicit.

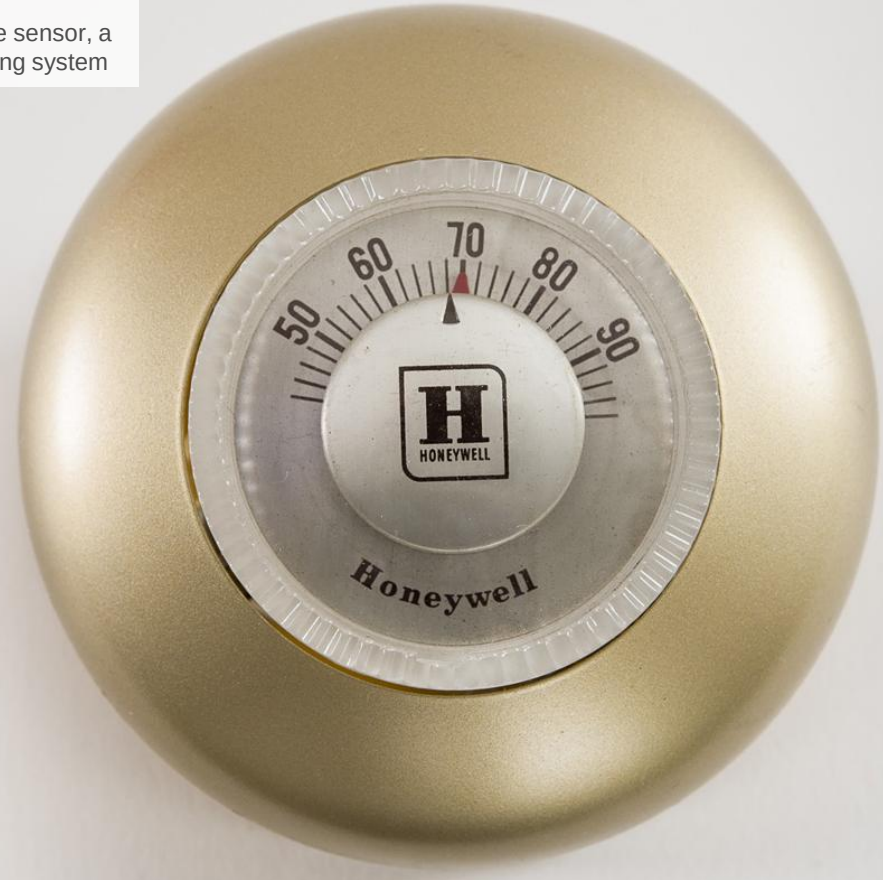




We can explore this concept a little further with the aid of simple case study… a bog standard, albeit quite beautiful, home thermostat

If we break it down and simplify things slightly, there are essentially four components.

We have a rotary dial, a temperature sensor, a switch and a connection to the heating system



Rotary dial

Connection to heating control unit

Temperature sensor (Bimetallic strip)

Switch

Captures user inputs

Display set temp

Rotary dial

Communi-cate with heating systems

Connection to heating control unit

Measures ambient temperature

Temperature sensor (Bimetallic strip)

Toggles state for heating control unit (on/off)

Switch

Each of these components has at least one function or affordance…
The dial captures and displays user inputs; the temperature sensor measures the ambient temperature, the switch toggles states and the connection allows communication with the system

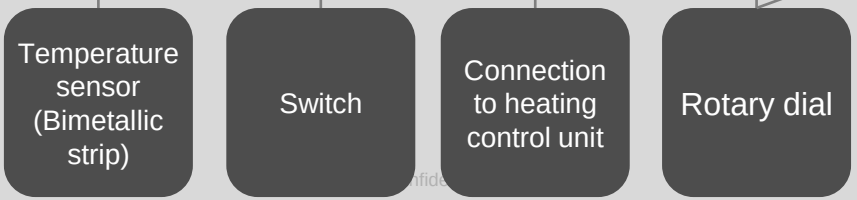
Domain purpose

Domain values

Domain functions

Physical functions

Physical objects



We can use a template called the abstraction hierarchy to capture this information.

We list the physical objects at the base and above it we capture the functions

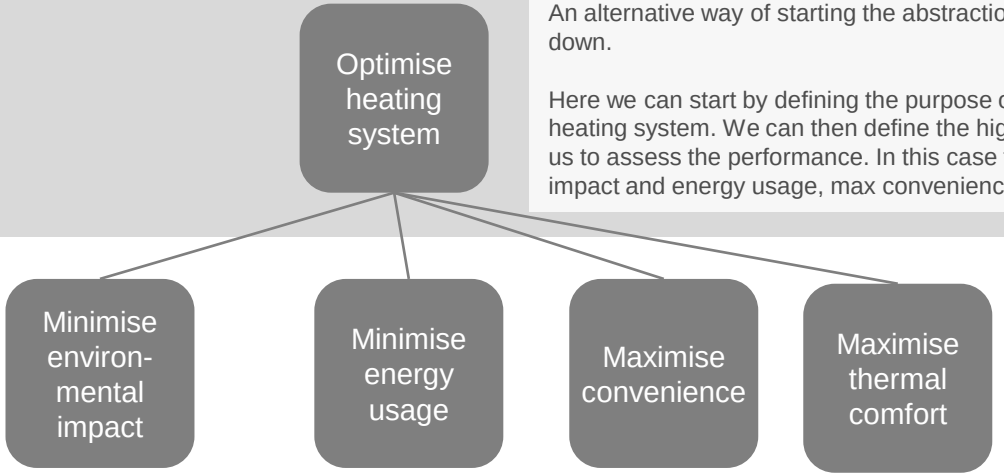
Domain purpose

Domain values

Domain functions

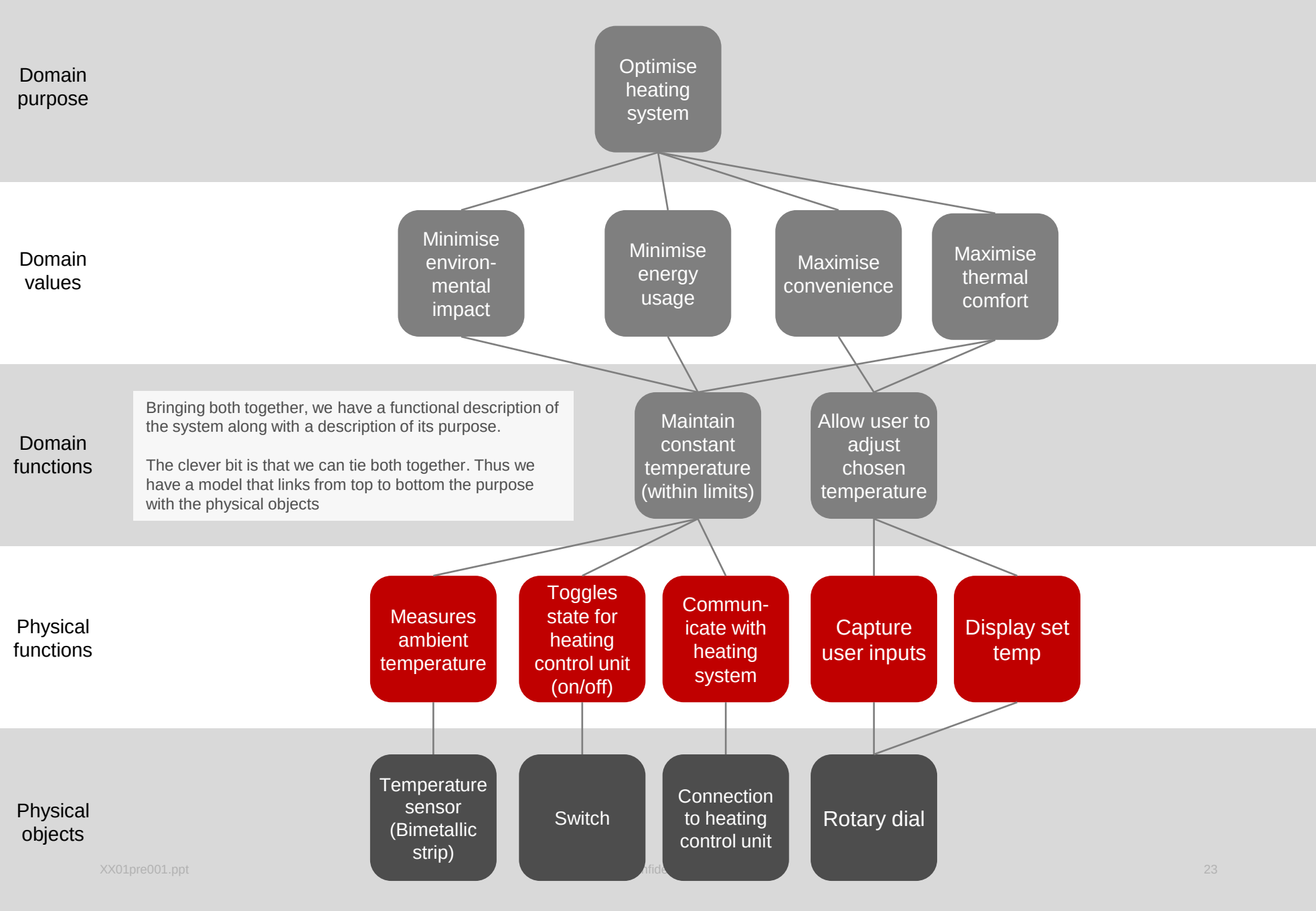
Physical functions

Physical objects



An alternative way of starting the abstraction hierarchy is to work top-down.

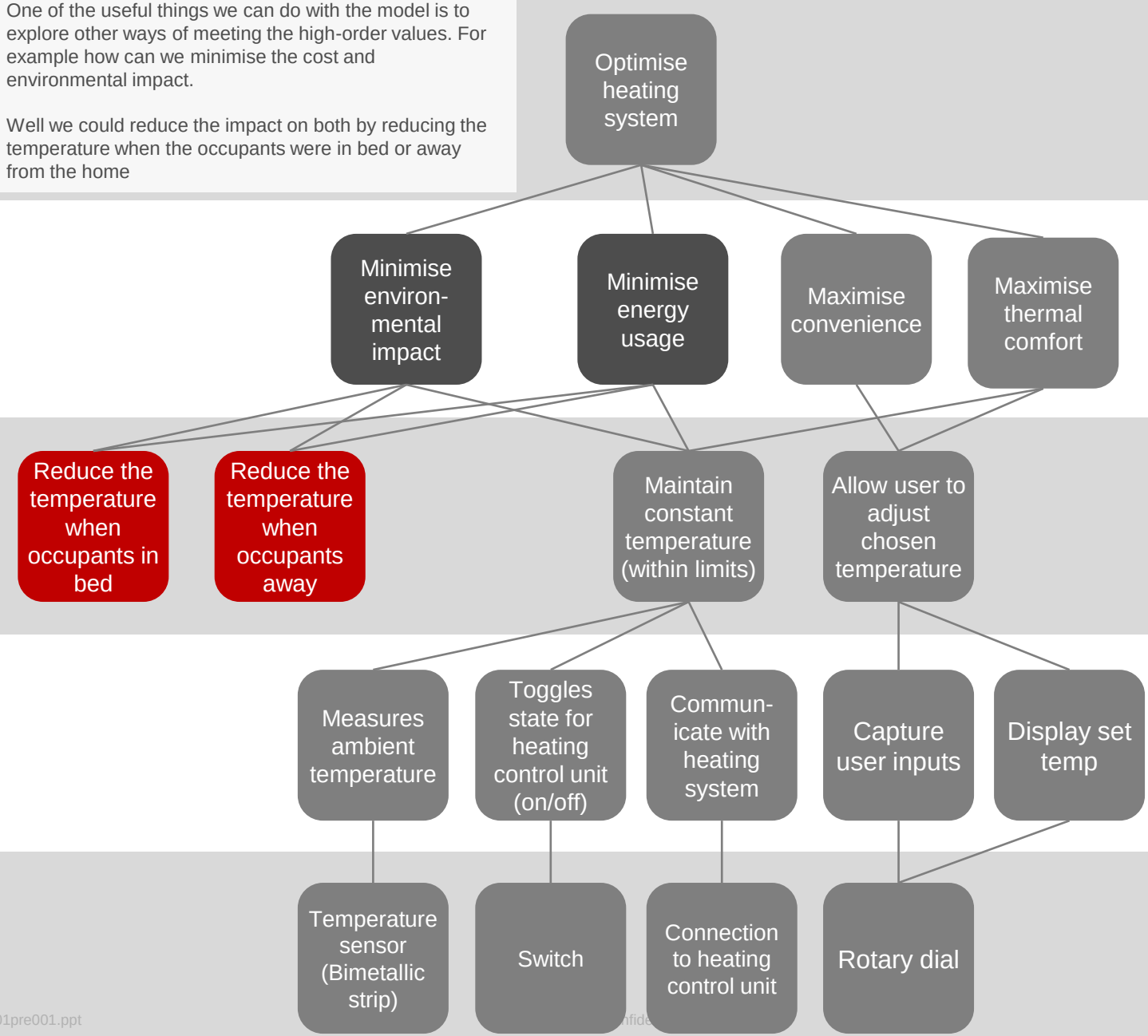
Here we can start by defining the purpose of the system – to optimise the heating system. We can then define the high level metrics that will allow us to assess the performance. In this case to minimise the environmental impact and energy usage, max convenience and thermal comfort

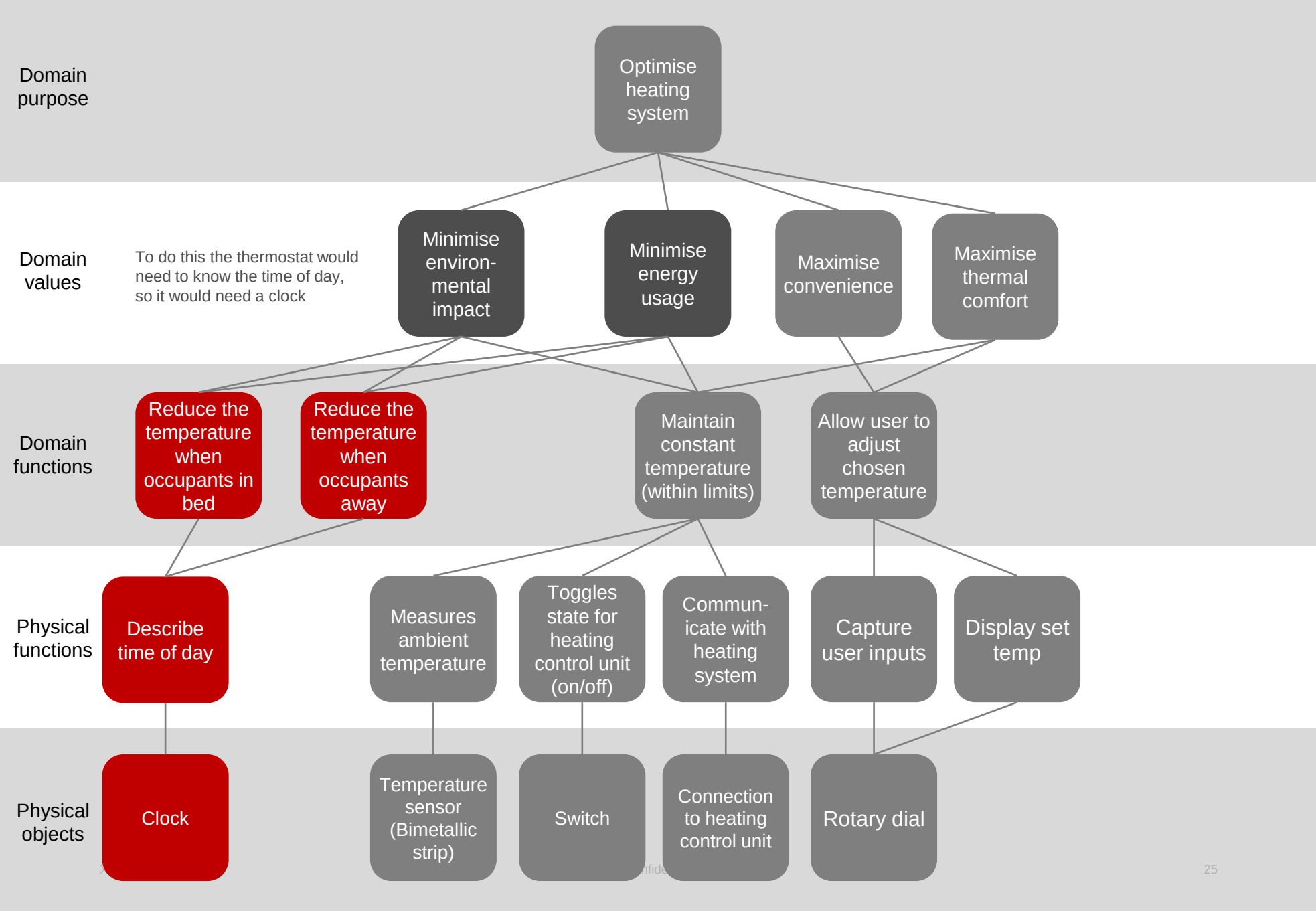

Domain purpose
Optimise heating system
Domain values
Minimise environ-mental impact
Minimise energy usage
Maximise convenience
Maximise thermal comfort
Domain functions
Bringing both together, we have a functional description of the system along with a description of its purpose.
The clever bit is that we can tie both together. Thus we have a model that links from top to bottom the purpose with the physical objects
Maintain constant temperature (within limits)
Allow user to adjust chosen temperature
Physical functions
Measures ambient temperature
Toggles state for heating control unit (on/off)
Commun-icate with heating system
Capture user inputs
Display set temp
Physical objects
Temperature sensor (Bimetallic strip)
Switch
Connection to heating control unit
Rotary dial

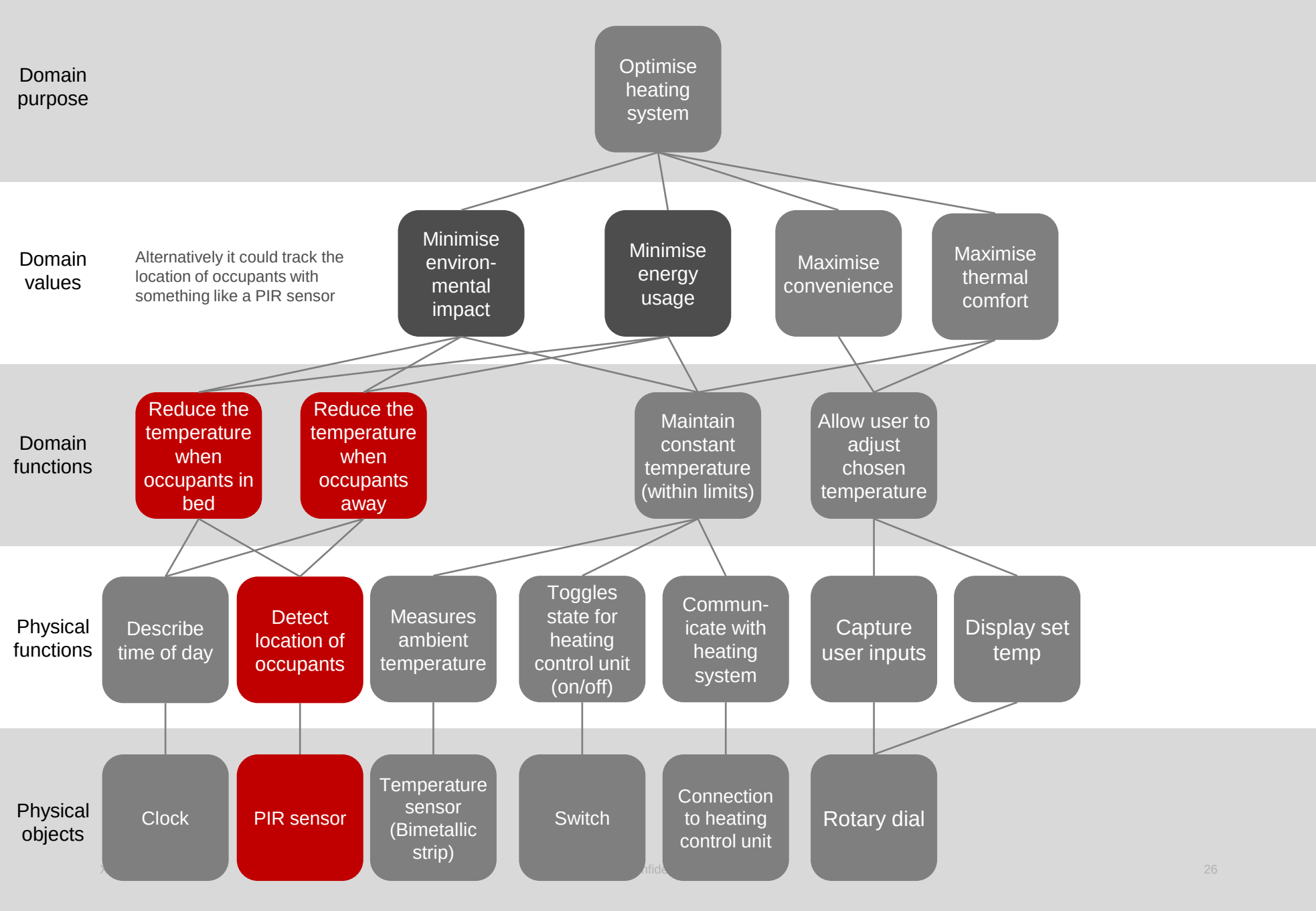
Domain purpose

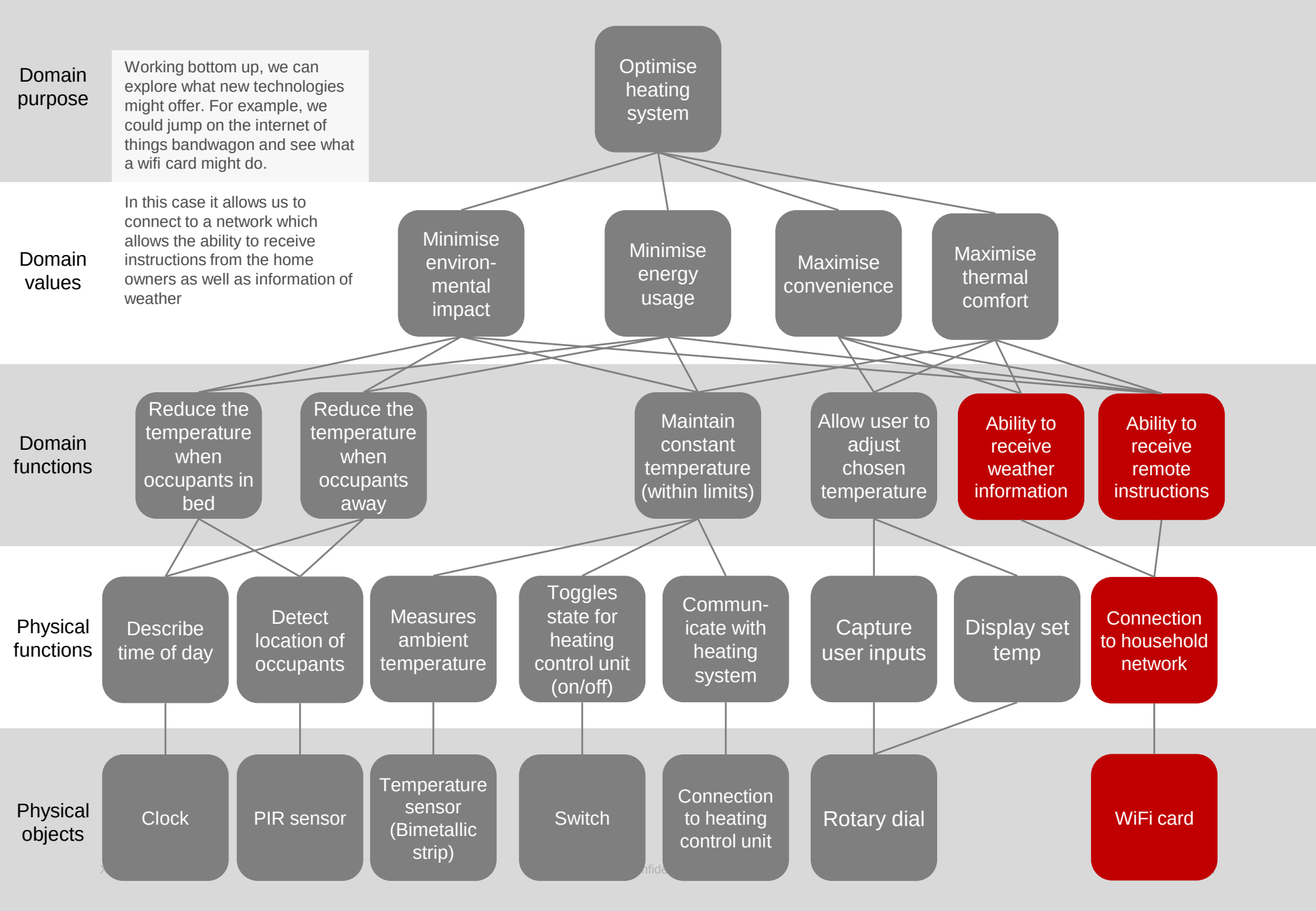
One of the useful things we can do with the model is to explore other ways of meeting the high-order values. For example how can we minimise the cost and environmental impact.

Well we could reduce the impact on both by reducing the temperature when the occupants were in bed or away from the home



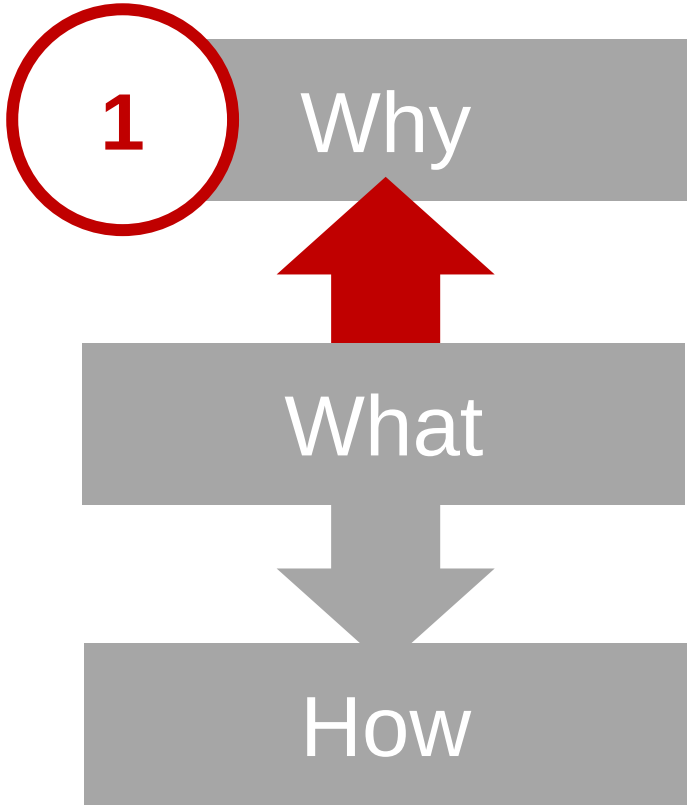

Domain purpose
Optimise heating system
Domain values
To do this the thermostat would need to know the time of day, so it would need a clock
Minimise environ-mental impact
Minimise energy usage
Maximise convenience
Maximise thermal comfort
Domain functions
Reduce the temperature when occupants in bed
Reduce the temperature when occupants away
Maintain constant temperature (within limits)
Allow user to adjust chosen temperature
Physical functions
Describe time of day
Measures ambient temperature
Toggles state for heating control unit (on/off)
Commun-icate with heating system
Capture user inputs
Display set temp
Physical objects
Clock
Temperature sensor (Bimetallic strip)
Switch
Connection to heating control unit
Rotary dial

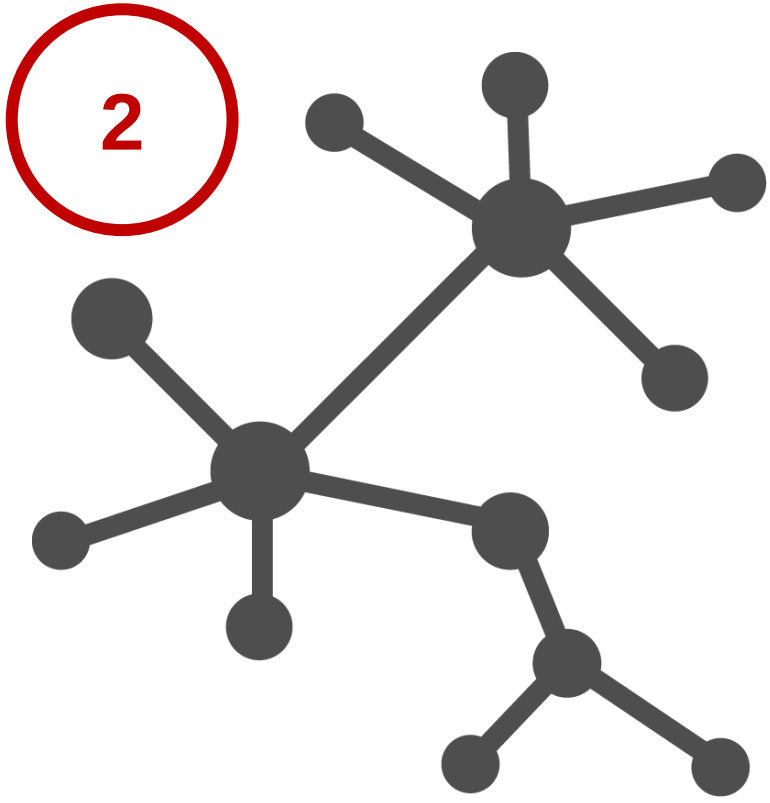

Domain purpose
Optimise heating system
Domain values
Alternatively it could track the location of occupants with something like a PIR sensor
Minimise environ-mental impact
Minimise energy usage
Maximise convenience
Maximise thermal comfort
Domain functions
Reduce the temperature when occupants in bed
Reduce the temperature when occupants away
Maintain constant temperature (within limits)
Allow user to adjust chosen temperature
Physical functions
Describe time of day
Detect location of occupants
Measures ambient temperature
Toggles state for heating control unit (on/off)
Commun-icate with heating system
Capture user inputs
Display set temp
Physical objects
Clock
PIR sensor
Temperature sensor (Bimetallic strip)
Switch
Connection to heating control unit
Rotary dial


Domain purpose
Working bottom up, we can explore what new technologies might offer. For example, we could jump on the internet of things bandwagon and see what a wifi card might do.
Optimise heating system
Domain values
In this case it allows us to connect to a network which allows the ability to receive instructions from the home owners as well as information of weather
Minimise environ-mental impact
Minimise energy usage
Maximise convenience
Maximise thermal comfort
Domain functions
Reduce the temperature when occupants in bed
Reduce the temperature when occupants away
Maintain constant temperature (within limits)
Allow user to adjust chosen temperature
Ability to receive weather information
Ability to receive remote instructions
Physical functions
Describe time of day
Detect location of occupants
Measures ambient temperature
Toggles state for heating control unit (on/off)
Commun-icate with heating system
Capture user inputs
Display set temp
Connection to household network
Physical objects
Clock
PIR sensor
Temperature sensor (Bimetallic strip)
Switch
Connection to heating control unit
Rotary dial
WiFi card

We can extend the model for something like the nest thermostat and at the highest level the model remains the same, the key difference is that we have added more detail at the base.

The grey shaded nodes indicate where the nest offers unique capabilities over a traditional thermostat



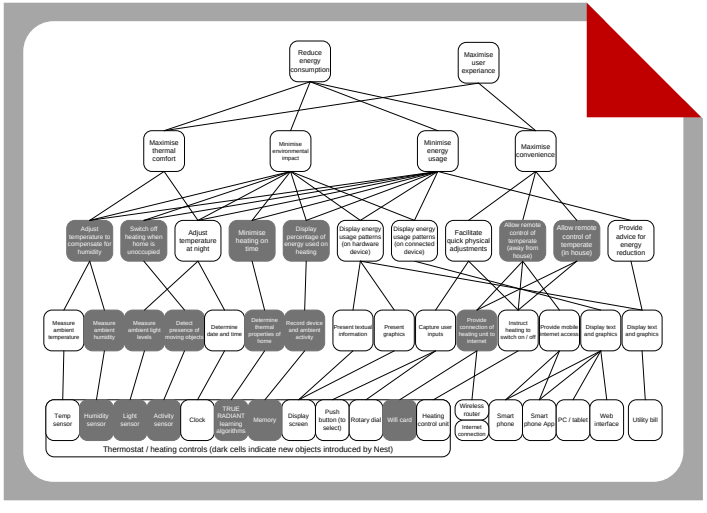


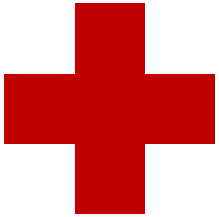
Ultimately, it is contended that the abreaction hierarchy does a very good job of meeting the objectives we discussed, namely that it provides a description of what a system must do as well how. More importantly it can also be used to create an explicit link to why a particular function is needed.

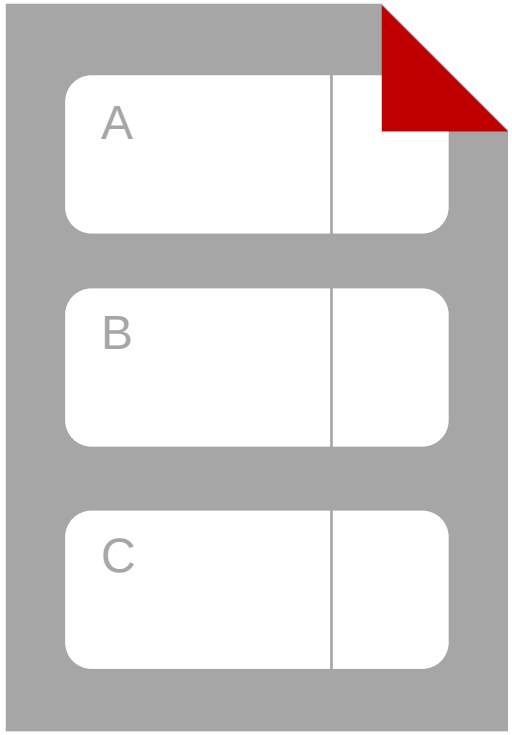
The second clear advantage is that it allows the design team to explore the interdependencies between the physical components in a system.

We certainly aren't suggesting that abstraction hierarchy should be a replacement for the traditional specification, rather we are suggesting that the two approaches are complementary .

Furthermore, there is no reason, why it has to be an abstraction hierarchy, there are many different systems modelling tools that could serve the same purpose.







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