This is a document containing the comments on Behavior that Chirs Nowak sent to the rest of the group by email on May 6, 2020. During the official meeting on June 12, Chris went through this document and the rest of members had the opportunity to ask and comment on their ideas.

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A supply chain network consisting of nodes, and links connecting the nodes, _functions_ by allowing and facilitating "flows" of products, goods, services, funds, contracts and information; it is also important that the flows are effective and efficient - and the network can adapt to the environment and flow requests by modifying itself, modifying nodes and links' properties, and modifying its topology by adding and removing nodes and links to/from the network. Although such systems might be seen as different than robots, they are not that different from teams of robots (or even a single robot processing in her head the supply chain network of sensory input, information, negotiation, contracts and decisions).

How could we understand behaviour/function/capability/structure of supply chains?

* capabilities: qualities of nodes/links that facilitate flows
* behaviours: flows (of goods, etc) through the supply network
* functions: facilitating the flows (making the goods move)
* structures: composition of nodes/links that give them the cap.

For many cases, it is not clear how capabilities, behaviours, functions and structures should be understood. Hence, additional discussions might be useful - in particular, it might be beneficial to consider specific subtypes of capabilities, behaviours and functions.

I have made the following list of items - my comments are below...

1. behaviour vs plan execution
2. some definitions
3. clarifying *FBS* frameworks ("FBS" - "function/behaviour/structure")
4. not separating behaviour from function, capability, structure
5. subconcepts of the concepts of behaviour, function, capability
6. autonomous robots vs complex adaptive systems (and complex networks)
7. is a supply chain network (SCN) an autonomous robotic system?
8. given an SCN, how to understand behaviour/function/capability/structure?

9. how important are abstract level capabilities, intentions, perturbations?

E. examples
  a) emergent behaviour (function/capability/structure - of emergence)
  b) internal behaviour (function/capability/structure - of internal behaviour)
  c) behaviour of moving (function/capability/structure - of moving)
  d) behaviour of sensing (function/capability/structure - of sensing)
  e) behaviour of planning (function/capability/structure - of planning)
  f) homeostatic behaviour (function/capability/structure - of homeostasis)

1. behaviour vs plan execution
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I used to associate (BDI) desires and intentions with "plans" (and plan construction and plan selection); and I used to associate behaviours with "plan executions" (and if a robot receives a plan as a request, we could assume that the robot's intention is to tranform requests into plans; additionally however, in a dynamic environment, the robot might need to be able to modify its plans). Given a robot, independently of whether the robot's plan is an explicit one, and implicit one, or only a "hypothesised one" (hypothesised by an external observer who comes up with the robot's plan in order to explain the observations), it seems that in order to talk about the robot's behaviour we need the robot's plan to be executed - until the robot executes the plan there is no interaction between the robot and the environment (w.r.t. the plan).

2. some definitions
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Several notions have been defined. Below, I list only the definitions of capability, behaviour and function:

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* capability *
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A capability is an individual quality of an object by which the object can participate in an event to maintain a state or to realize a change provided the initial situation is of a certain type

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* behaviour *
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A behavior of an object (including robots, agents and devices) is the way the object interacts with its environment as well as the way its environment interacts with the object.

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* function *
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A function of an object (robot, agent, device) is a role that the behavior manifested by the robot play in an event

****
* func.exec. *
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A function execution is an event in which the behavior of an object (robot, agent, device) plays a role with respect to a goal

% action: An action is a function execution

****
* structure *
****

% no definition has been provided

I believe these definitions are essential - they form the first step in the process of constructing an ontology of capability-behaviour-function.

But, it would be useful to make the next step: to consider sub-concepts of these concepts...

3. clarifying *FBS* frameworks ("FBS" - "function/behaviour/structure")
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When we start talking about capability/behaviour/function, it seems appropriate to consider some ***FBS* frameworks ("FBS" - "function/behaviour/structure")**, including the following:

the function-behavior-structure model of Gero
the function-behavior-state model of Umeda
the structure-behavior-function model of Goel
the functional basis of design of Stone & Wood
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some references to the above can be found in:
[BCGV09]
Stefano Borgo, Massimiliano Carrara, Pawel Garbacz, and Pieter E. Vermaas.
A formal ontological perspective on the behaviors and functions of technical artifacts.
Artificial Intelligence for Engineering Design, Analysis and Manufacturing, 23:3–21, 2009

In particular, it would probably be beneficial to provide short and simple justification for using the above definitions rather than those of Gero/Umeda/Goel/Stone & Wood.

4. not separating behaviour from function, capability, structure
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One could focus on the concept of behaviour - and put aside (at least for a while) the concepts of **function, capability, structure**. But it seems to me that these concepts are intertwined and should not be separated.

5. subconcepts of the concepts of behaviour, function, capability
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As said in (2), the definitions form the first step in the process of constructing an **ontology of capability-behaviour-function**; considering sub-concepts of these concepts can be seen as forming the next step (another step might be to construct a taxonomy and a partonomy containing these concepts, and considering other relations than subsumption and part-whole).

Some subconcepts of the concepts of behaviour, function, capability
are considered below, in examples E/(a-f)

6. autonomous robots vs complex adaptive systems (and complex networks)
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I believe that autonomous robots (and autonomous systems in general)
should be seen as complex adaptive systems (which, in the discrete
case, can be modelled using complex networks). The environment needs
to be assumed to be complex, unpredictable and dynamic - and therefore
our systems should expect "perturbations" and should be adaptive (in
order to handle perturbations).

7. is a supply chain network (SCN) an autonomous robotic system?
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I think that a robot, or a robotic system, should not only be able to
do something (say, perform a "task" - maybe a one-off task, or acting
reactively according to a simple procedure), and should not only be
automated, but also be autonomous. To me, this means that it should
be able to handle perturbations - while maintaining its functionality,
and occupying stable states (that could be defined as states in which
it can function well).

I would be tempted to say that an adaptive supply chain network (that
can handle perturbations while functioning) is an autonomous robotic
system. But what's important is not particular formulations of our
definitions (having multiple definitions solves this problem), but
building systems that function well.

8. given a SCN, how to understand behaviour/function/capability/structure?
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I suggested above that, given a supply chain networks (SCN), we could
have the following:

* capabilities: qualities of nodes/links that facilitate flows
* behaviours: flows (of goods, etc) through the supply network

* functions: facilitating the flows (making the goods move)
* structures: composition of nodes/links that give them the capab.

I'm sure the above will need to be corrected/changed/clarified.
Again, what's important is to have SCNs that function well in complex
(dynamic, uncertain, partially observable) environments.

9. how important are abstract level capabilities, intentions, perturbations?
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I said before that I believe that Dennett's intentional stance - which considers physical, design and intentional levels - is a useful approach. In particular, I think that we can consider physical and design level capabilities (and corresponding functions and behaviours). I think "physical capabilites" are "concrete" - while design level capabilities are more abstract.

The physical "capability to move" will take into account physical laws, and things like friction, slippery ground, wind, road surface (for land vehicles) or tides and currents (for water vehicles). The design level "capability to move" would be more abstract - an example: is x capable to move from A to B? A plan for x might contain a statement "move from A to B" - and this part of the plan might be executed successfully - without the observer even noticing the intricacies of the physical level; but when the execution of the plan fails, then the physical level analysis needs to be performed, and re-planning must take place.

Regarding intentions... sensory input, communication, information, beliefs, desires and intentions need to be processed in order to make decisions and form plans. It is the intentional level processing that processes x's beliefs and desires - in order to produce the intention to move from A to B, which then becomes a part of the plan, and eventually gets executed. This means: we do need the intentional level capabilities.

Regarding perturbations... above the intentional level there is the level of the complex environment perturbs the world in which our systems function. The systems must be observing the environment and they must be handling the perturbations. When a perturbation occurs, the intentional level processing is perturbed - intentions and plans

need to be revisited and adjusted. This means: we do need the perturbation level - or metabolic - capabilities.

E/a) emergent behaviour

Emergent behaviour is usually the result of interaction involving multiple systems. For instance, the behaviour (and the capability) of a pair of fighter aircrafts is a qualitatively new thing; we can find similar behaviours/capabilities in (dolphin/wolf/...) pack hunting. Other types of emergent behaviour includes flock of birds behaviour, school of fish behaviour, etc. Such pack/school/flock/team behaviour cannot be exhibited by individuals - it requires team interaction. I'm not considering details here - but we should be able to clarify some details, for some "emergent team behaviour" cases. There might be other types of emergent behaviour, not involving teams (of individuals); maybe a change in the environment modifies the usual behaviour, and a new behaviour emerges. But emergent team behaviour might be an interesting case to consider.

E/b) internal behaviour

By "internal behaviour" we might mean a behaviour that is different than "externally observable behaviour" - internal behaviour would then be impossible, or difficult to observe. Black box systems (when inspecting the inside of the box is not possible) and minds would be typical examples. When a robot does her thinking, we might be unable to observe the process (the process of manipulating beliefs, intentions, constraints, obligations - aimed at deriving decisions). However, thinking behaviours might be different - for instance those behaviours could depend on different (reasoning) logics employed by the agents/minds; I would think that it would be appropriate to understand "thinking behaviours" as "internal behaviours" which might (and usually are) un-observable. But we could easily imagine a scenario where our robot reports (in real time) on her beliefs and intentions (explainable AI)

Again, I'm not providing details here - but we should be able to analyse some kinds of internal behaviour - from the function/capability/structure/behaviour perspective.

E/c) behaviour of moving
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* capability of moving:
  quality of an object by which the object can participate in a
  movement event

* behaviour of moving:
  the interaction of the object with the environment resulting
  in the object changing its location within the environment

* function of moving:
  the _role of movement_ that the behavior manifested by the robot
  plays in an event

E/d) behaviour of sensing
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* capability of sensing:
  quality of an object by which the object can participate in a
  sensing event

* behaviour of sensing:
  the interaction of the object with the environment resulting in the
  object obtaining information about other objects within the
  environment

* function of sensing:
  the _role of sensing_ that the behavior manifested by the robot
  plays in an event

E/e) behaviour of planning
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* capability of planning:
  quality of an object by which the object can participate in a
  planning event

* behaviour of planning:
  the interaction of the object with the environment resulting in the

object constructing a plan to be executed within the environment

* function of planning:
  the _role of planning_ that the behavior manifested by the robot
  plays in an event

E/f) homeostatic behaviour
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* capability of homeostatic control:
  quality of an object by which the object can participate in a
  homeostatic control event (event of returning/moving to a stable
  state, after perturbation)

* behaviour of homeostatic control:
  the interaction of the object with the environment resulting in the
  object using homeostatic control mechanisms and (as a result of
  using these mechanisms) returning/moving to a stable state

* function of homeostatic control:
  the _role of homeostatic control_ that the behavior manifested by
  the robot plays in an event

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Definitions in (2) have beed provided by Stefano, and can be found in
the "Autonomous Robot Standard" document.

Regarding the example E/a, I believe Stefano suggested that we
consider "emergent behaviour"