Massimo Franceschet Presentation

Following this introduction, I had two choices: to enter the room or not to.
Either way, I would have ended up with one of two possible futures.
Physics of the last century showed an ancient intuition of Eastern mysticism.
That is to say that the world, the space in which we live, it is a complex web, a dynamic network of pulsating events.

As per Carlo Rovelli, *"Not only can things relate to one another, but it is these relationships that give rise to the meaning of things".*

I am a researcher at the University of Udine; coincidentally I deal with newtorks.
Networks are an extremely simple model, very fulfilling, but also omnipresent: the Internet, the Web, social networks and even our brain.

What fascinates me about networks is that they embed three interesting models that I will attempt illustrating to you during this presentation: the Linear Model, the Branching Model and the Circular Model, and are all represented in this network. Or graph, as labelled by mathematicians.

Let's start with the Linear Model, what is the Linear Model?
The Linear Model is a ceaseless succession with no room for alternative paths, it corresponds to the concept of "Fatalism" and it can be displayed as a path, therefore as a succession of points.

I will explain this model by using the phenomenon of the "6 Degrees of Separation".
Does anybody know about the "Small World Phenomenon"?
Well, maybe, a couple of my students do since I taught it this year, and a few of them are present here.
The Small World Phenomenon states that: if we choose a random person on Earth, like a mechanic in Tihuana, Mexico or a greengrocer in Perth, Australia, how many degrees of separation separate us from these people?
If I knew the mechanic directly there would only be one degree of separation, if I knew him indirectly that is through another person, maybe a friend of mine who studies Mexico, there would be two degree of separation instead and so on.

The Small World Phenomenon reads that even though the world is big, a vast network in terms of nodes, actors, the distances between people, between actors, are actually very small.
In mathematical terms we say these are logarithmic with respect to the number of nodes. Therefore, incredibly small.

At the beginning of last century, in 1929, an almost unknown writer named Frigyes Karinthy wrote a short story called "Chains", from which I have extracted this paragraph.
He imagined picking one person among, at the time, 1.5 billion that lived on earth and bet that within no more than five intermediate people, that is, in no more than six steps, he could reach these people through ones' personal network.
He is the first person to realise this phenomenon, but on literary level, in the sense that his intuition is pure fantasy.

I find it surprising that 40 years later, in 1967, a famous American psychologist named Stanley Milgram conducted an experiment on the Small World and somehow confirmed Karinthy's intuition.
What does Milgram do? He grabs a phone book, the Internet was not around back then, he randomly selects 100 people and asks these people to send a letter, a package, an envelope to an addressee who lives 1000 km away. However, they must send it through a personal network.
Eventually he visits a friend, collects the envelopes, of course some were lost in transition, on each envelope was written down the people it was passed on to, he calculates the average distances and the result is the number six.
Actually, it was 5.9, from which came the myth of the 6 degrees of separation.
This hypothesis, this idea of the Small World, of a world that despite being so big, it is connected through small distances between individuals.
The experiment was then repeated, and confirmed once again in collaboration with the Polytechnic of Milan, using Facebook's network, with a much larger sample than Milgram's, a sample of 1.5 billion people, the very same number of people Karinthy envisioned on earth 80 years earlier.
As of today, the degrees of separation have been reduced to 4.5.

The second model I would like to tell you about is the Branching Model. It implements the concept of “Free Will” and can be represented as a tree of choices and paths, of possible futures.
A garden of forking paths.
Temporal reasoning, so we are talking about time, has very ancient roots and it dates back to the time of ancient philosophers.
Aristotle is the first to ponder over temporal matters and proposes the “Problem of Future Contingents”. What are “Future Contingents”?
These are propositions that refer to future events. Aristotle asked himself to use this proposition:
“Will there be a naval battle tomorrow?”, or, reformulated in modern times, "Will there be an earthquake tomorrow?" or “Will the sun rise tomorrow?”
Aristotle asked himself; can we define a truth-value, within a binary logic of true or false, for these statements? Nowadays can we tell if these statements are true or false?
Well, in her homely wisdom my mother would say, “only God knows”.
Many centuries following Aristotle, William of Ockham, with all due respect, gave a rather similar answer; he stated that the answer was not within the mind of men but in the mind of God.
In reality Ockham attributes to men a very important ability, the ability of Free Will, therefore the ability to choose between many, to make choices and thus, to create differing possibilities, differing paths, differing yet possible futures, and in a certain sense this explains, it gives a solution to, Aristotle’s Problem of Future Contingents.
Or, in other words, these statements are not inconsistent if we interpret them on a tree structure wherein there are many possible futures.
As I somehow played at the beginning, there is a future in which I presented myself and gave this speech and another where I sat back and enjoyed my relaxing tea, therefore it is perfectly legitimate that in some of these futures an earthquake also happens or a naval battle also takes place, while in others neither take place instead.
Or that in all of these futures the sun will rise tomorrow or that the Earth will end.
It is interesting to see how in the 1950s a New Zealand philosopher and logician, Arthur Prior, studied these theories, Ockhams in particular, and defines the concept of temporal logic, the so called Branching Time Logic, of which you see the four main operators and their interpretation of tree structures, but I won’t go any further.

I find it interesting that temporal logic, born from these philosophical discussions, is as of today still relevant to applications in artificial intelligence, for example, to represent and reason on temporal knowledge, and in computer science, to analyse the behaviour of nondeterministic reactive systems.

The third model I would like to tell to you about, perhaps the most important and even most surprising, is the self-referential or circular one.
It is a path that rethreads its own steps, a cycle as we call it in graph theory, an Oroborus, a snake which eats its own tail.

Self-referentiality, or recursion in mathematics, is surprisingly present in nature and assumes the form of a fractal.

Here you see roman broccoli that, besides being very delicious, is also a perfect example of a fractal; what is a fractal then?
A fractal is a geometric figure, which repeats on differing scales.
To your right you have the image of a fractal, of broccoli as a whole, to your left an aspect of it, a form that has a certain type of self-referentiality, a sort of “circularity”.
This is self-referentiality in nature.
This is self-referentiality in mathematics. Showing off mathematical equations at TedTalks is always risky.
But I actually care a lot about this equation, firstly because it is a beautiful equation and I challenge anyone to say that this is not pure poetry.
And secondly, it is a very useful equation; you use this equation everyday, because this equation is at the heart of an algorithm called PageRank. And the PageRank is the algorithm used by Google Search to sort webpages as per your requests.

Paraphrasing the meaning of the equation, giving an interpretation to these mathematical symbols we could read the equation as follow: It says that an actor within the network is important if other important actors surround it.
Have you noticed the circularity of this at all? I am defining something in terms of itself.

A self-referentiality, a tautology we would say in logic, even though there exists a well defined solution, syntactically speaking where does the recursion lie?
Well, lambda is a number, “A” is a matric, an algebraic structure used to codify, to represent a network, and "x" is a vector, so you can’t simplify the "x", as someone said yesterday.
These structures are very different from one another.
The recursive nature is within the fact that “x” appears to the left and right of the equal sign; hence I am trying to define something in terms of itself, pure magic from my point of view.

One of the papers that has given me the most satisfaction was the one of studying the history of this equation. Besides, who ever thought of studying the history of an equation anyway?

It appears that the first to have used this were 1950’s sociologists who affirmed that a person is prestigious if they receive approval from other prestigious people.

In 1970 it was discovered in bibliometrics too, a journal is influent if other influent journals cite it.

In the 1990s it was popular in sports, a team is strong if it beats strong teams.

And lastly in the 2000s, two PhD students of the American University of Stanford, namely Sergey Brin and Larry Page, discover once again this recursive mantra and turn it into the pulsating heart of the Google Search Engine, which will undoubtedly become very popular.

This is not the only equation, there is also another. This one too happens to be my favourite.
At the University of Udine we studied, alongside my colleague Enrico Bozzo, a variation of this equation.
It connotes the concept of power, not the concept of centrality, or of importance, and it could be defined as: “an actor is powerful if it is surrounded by actors who are powerless”.
This too is a recursive equation, as you can see “X” appears to the right and to the left of the equal sign.
We applied it within an economic context of bargaining, if I have to negotiate with someone; my negotiation power is high if my contractors are not very powerful. If on the other hand, my contractors are very powerful themselves, for example, if my contractors are called Google, Apple, Microsoft, then clearly my negotiating power is very limited.

In our case we applied it to the distribution network of natural gas across Europe, which you can see here outlined as an indirect graph.
The node’s dimension is proportional to the power of that node; hence as you can see large nodes are close to small nodes and vice versa.
This is the concept of power.

Getting back to our own steps, we started by saying that space, as we similarly heard this morning from Francesca Vidotto, space is a network, it is a network of events, so why not propose an original idea during these final moments: time is a network, a network of time.
After all, network models follow the linearity, the branching and even circulatory nature that time displays.
Unfortunately, the margin of time that separates me to the end of this intervention, is too small to investigate this brilliant intuition any further; perhaps we could ask a few theoretical physicists if it makes any sense.
All that is left for me is to leave you with one of the most beautiful quotes about time that has ever been suggested to me, which is to wish you all the beauty that this world has to offer.