# Group 9: BBB - Exploring Bianconi-Barabasi Networks

**Background of our project:** The Barabasi-Albert model uses the concepts of growth and preferential attachment (based on the degree of the nodes) to evolve into a complex network that has a scale-free degree distribution. However, due to the fact that the preferential attachment is only based on the degree of the nodes, the model cannot take into account a phenomenon where nodes that might emerge later could also have the potential to become a large hub. An example of this is Google in the World Wide Web network, which came into existence relatively late but still became one of the most connected nodes. Therefore, we will explore an extended version of this model,  the Bianconi-Barabasi model. In this model, every node is assigned a fitness value, which is used together with the degree to determine the preferential growth. Depending on the distribution that is used to sample the fitness values, there is a phase transition possible that closely resembles a phenomenon that occurs in physics, known as the Bose-Einstein condensation.

**Research question:** How does the degree distribution in the Bianconi-Barabasi model depend on the fitness distribution in the network? Simultaneously, can we find the fitness distribution of real-world networks based on the time evolution of the degree of the nodes? Finally, can we observe the phase transition where a finite fraction of the nodes is linked to a single node?

**Hypotheses:** The degree distribution will follow a power-law, precisely like the BA model, if the fitness distribution has a finite domain. The node with the highest fitness value will draw a lot of other nodes in the second instance if the fitness distribution has an unlimited domain, resulting in a situation winner takes all phenomenon. We will therefor find in the plots a powerlaw disitbution with the exponent comparable to 2.25 (from analysis).

It is possible to recreate the fitness distribution based on the degree distribution of real-networks that were created in a Biaconni-Barabasi fashion.

**Which model**. Bianconi-Barabasi network.

**Emergent phenomenon of focus:** Phase transition. Degree distribution plots wrt fitness (Network analysis). Degree distribution plots wrt temperature drop (Bose-Einstein condensation).

**References:**

  Bianconi, & Barabási, A.-L. (2001). Competition and multiscaling in evolving networks. Europhysics Letters, 54(4), 436–442.<https://doi.org/10.1209/epl/i2001-00260-6>

  Bianconi, & Barabási, A. L. (2001). Bose-Einstein condensation in complex networks. Physical Review Letters, 86(24), 5632–5635.<https://doi.org/10.1103/PhysRevLett.86.5632>

Barabási, Albert-László. "Network Science." *Network Science* (2016)

## Progress/time planning

**Week 1:**

* **Monday**: Refine project deliverables. Discuss how planning is gonna go, distribute implementation work to group members.
  + Who is working out the math?
  + Who is working out the network implementation?
  + …
* **Tuesday**: Implement Network model, look into what kinds of plots we want. Find time-data on network growth for 2nd question.
* **Wednesday:** Continue implementation of the network + Make the first slides of the presentation on the theory of the network.
* **Thursday**: Re-evaluate the progress, set nice to haves. Final day to find useful data and set goals on what is achievable with this data.
* **Friday**: Finish implementation of the network analysis. Continue real-data network analysis and development.

**Week 2:**

* **Monday:** Start-up meeting: what are we feeling that needs to be done the rest of the week? Start implementing code for phase transition detection.
* **Tuesdays:** Decides what can still be done before wednesday (--> Last day of development).
* **Wednesday:** Finish the must haves, start making a storyline for the presentation
* **Thursday:** Finish up the plots for the presentation, and the rest of the presentation
* **Friday:** present and code cleanup. We want to be able to hand it in at the end of the day.

## Questions/Issues

* How are we plotting the phase transition à How do you PROVE that it is actually a phase transition?
* How would we identify preferential attachment in network data (2nd question)