

Carbon footprint of Google search using AnyLogic

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Introduction

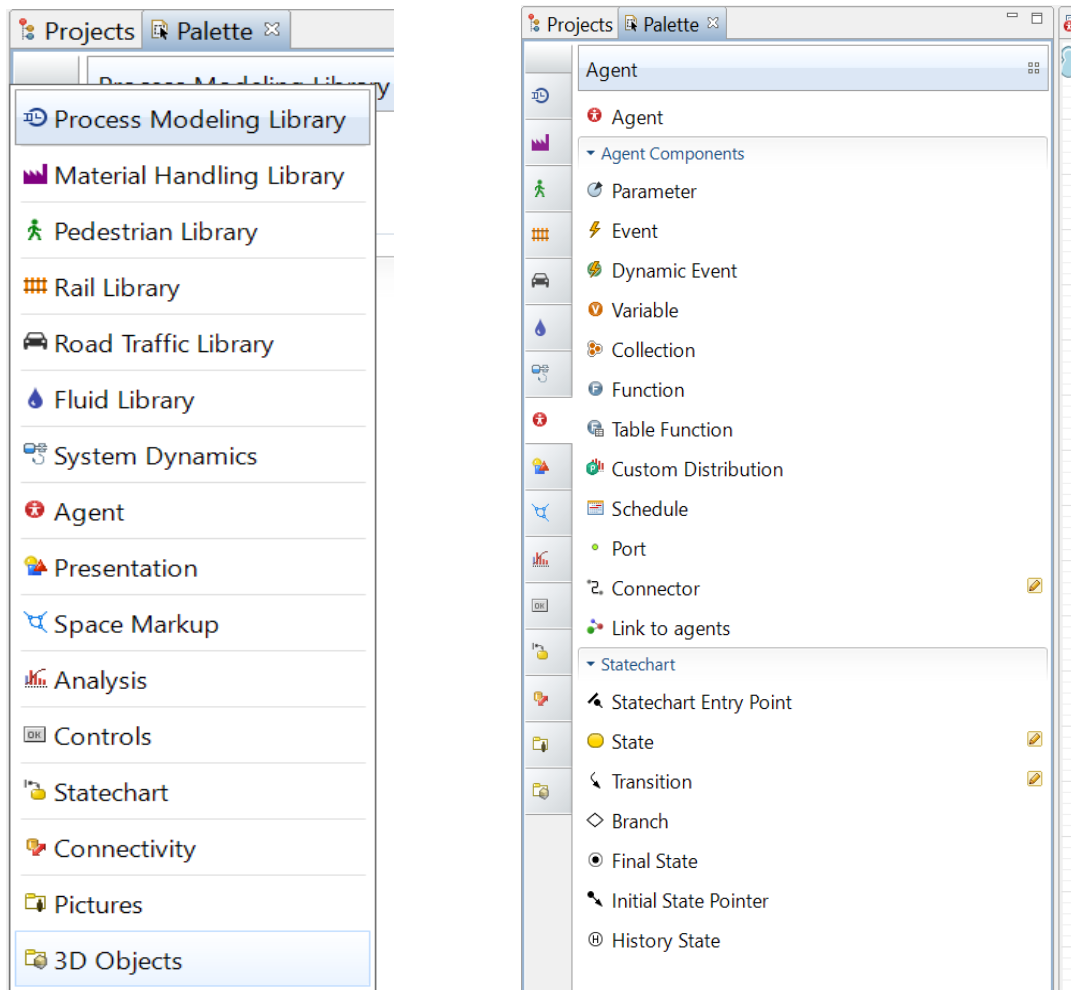
This report is for the MAS project which was to create an Agent Based Model using AnyLogic to see the effects of Google Search engine. As quick as Google search results are they do consume energy while looking for results which contributes to CO₂ emissions into the environment. The aim is to see how these seemingly benign searches can have an impact on the environment. I used AnyLogic as my choice of software to simulate this scenario. It has a huge library of versatile software packages for systems modelling.

Project Topic

The intangible nature of the internet makes most of us assume that it exists but in a “cloud” somewhere, both literally and figuratively, and is therefore harmless. But there is a cost of existing on the cloud. As the world shifts from physical form to bits and bytes the effects of going “paperless” in all aspects need to be encountered. Storing and retrieving all this data consumes a lot of energy. Every Google search emits 0.2 grams of CO₂. The number sounds negligible until you consider that a huge chunk of the world’s population is consuming information via internet, Google being the most popular choice. The aggregate seems to grow drastically. Not to mention that 0.2gms is after considering that Google uses renewable sources to fulfil its energy requirement. In addition to this there are multitudes of Servers in several Data centres running day and night. They consume an excessive amount of energy for existing in terms of just staying live and the energy used to keep the surrounding temperature of the datacentres cool enough for them to function.

AnyLogic

- For this project I used AnyLogic, which is a multimethod simulation modelling tool.
- It is a cross-platform simulation software that supports not just agent-based but also discrete and system dynamics simulation methodologies.



AnyLogic provides multiple libraries which contain several relevant components

- AnyLogic being a multimethod tool provides in-built libraries for various fields like transportation, manufacturing, business processes etc.
- Each library offers several components necessary for the specific field.
- It is user-friendly and gives access to multiple tutorials and example simulation methods.
- It also comes with GIS integration, Model animation and database connectivity. Some features are not available in personal use edition and require an upgrade.

About the Project

The project involved learning to use AnyLogic and modelling the contribution of Google search in carbon emissions. Both the things were vast in scope.

- AnyLogic is a very complex software with too many features to understand everything. It sometimes was hard to decide what feature best suits my model.
- Google search as a process is quite difficult to track. There could have been uncountable agents, each with different complex scenarios of energy consumption.

Agents

- Google search can be done using several gadgets with varied energy consumption, so I chose to stick with generic “device”.
- Data centres consume a lot of electricity irrespective of answering queries.

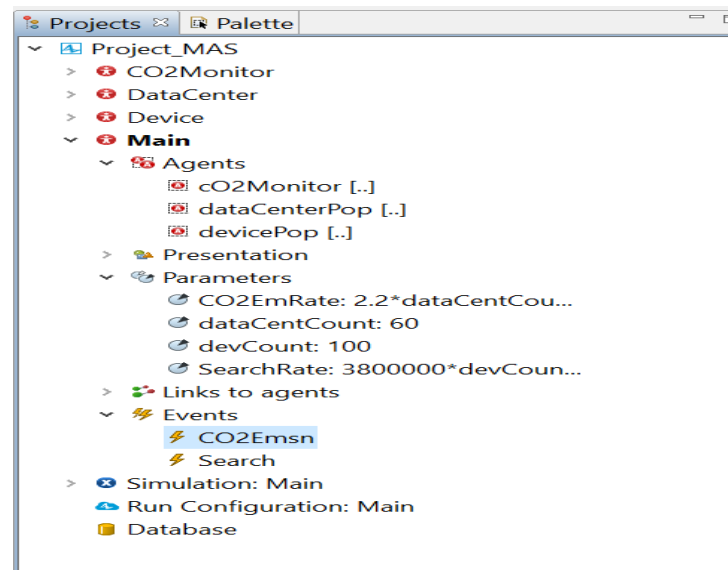
METADATA

- Each search emits 0.2gms of CO₂ and google answers 3.8 billion google searches per minute.
- Google used 12749 gigawatt hours of electricity in 2019 to maintain its data centres.
- The carbon intensity of grid electricity is based on the international average as reported by the International Energy Agency (475 grams CO₂e per kWh) and renewable energy is based on data for wind energy from Electricity(33.4 grams CO₂e per kWh).
- Assuming half of the energy consumption is through renewable resources 3027888 metric tonnes of CO₂ emissions plus 212908.3 metric tonnes. Overall 3,240,796.3 metric tonnes

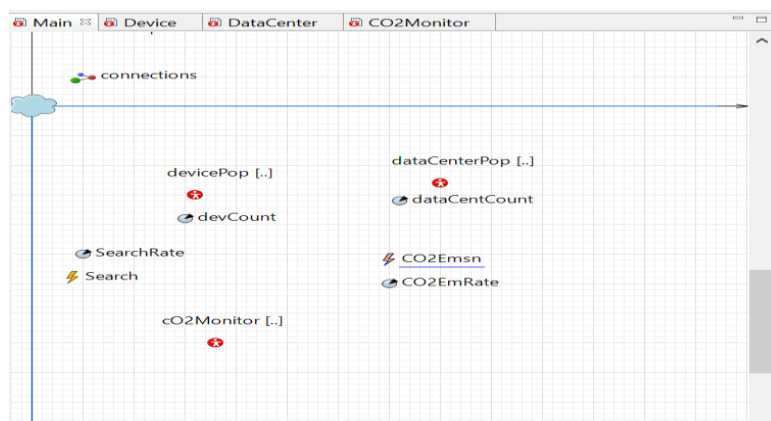
- I used the above data to evaluate the role of the agents in the simulation.
- To visualise and keep track of carbon emissions CO₂ monitor agents were created. In essence though they basically signify a quantum value of CO₂ emissions.

Parameters

- The agent populations are controlled and initiated by population parameters. It also makes it easier to create multiple simulations with varying values.
- I also created rates parameters to compute the rate at which search requests are being sent and the rate at which carbon dioxide is being emitted.

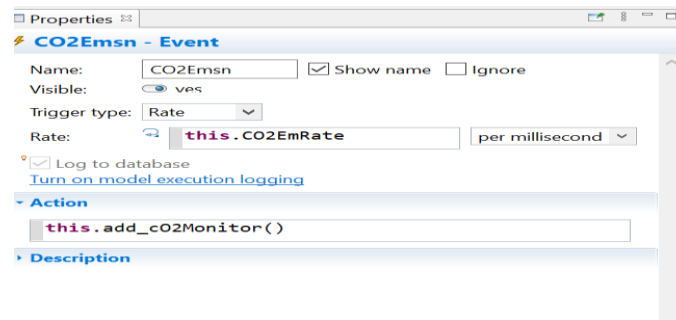


Elements of the model



Events

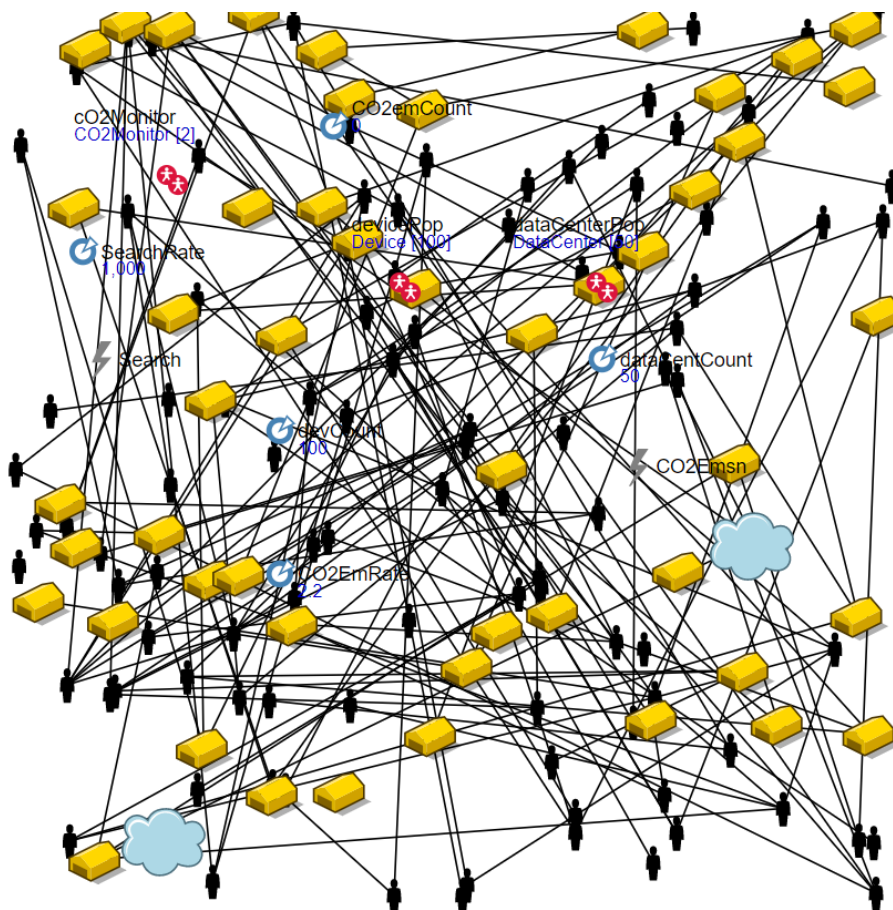
- Events are components that allow agents to create transitions and flows.
- It can be done by using state transition charts or flow diagrams.
- Event seemed more suitable for my requirement.
- The major events taking place in the scenario are the search requests and the carbon emission because of those search requests.



Modelling and Simulation

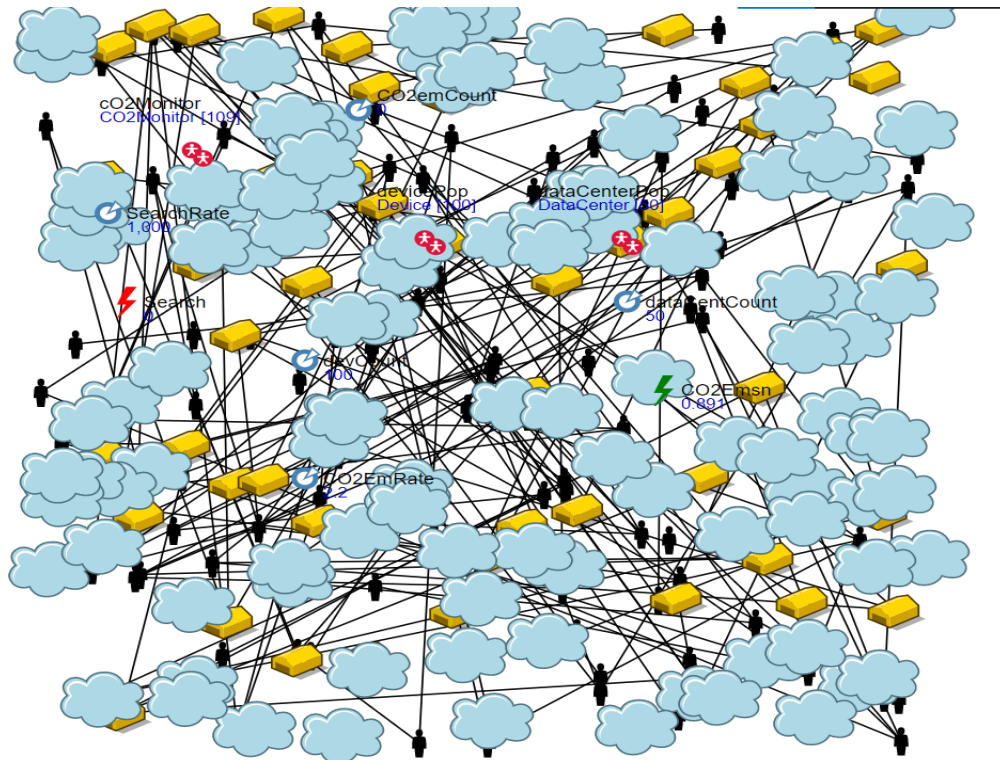
AnyLogic allows the functionality of creating multiple Experiment simulations where we can see the model work with varying parameter values.

- The number of devices connected contribute to the number of search requests

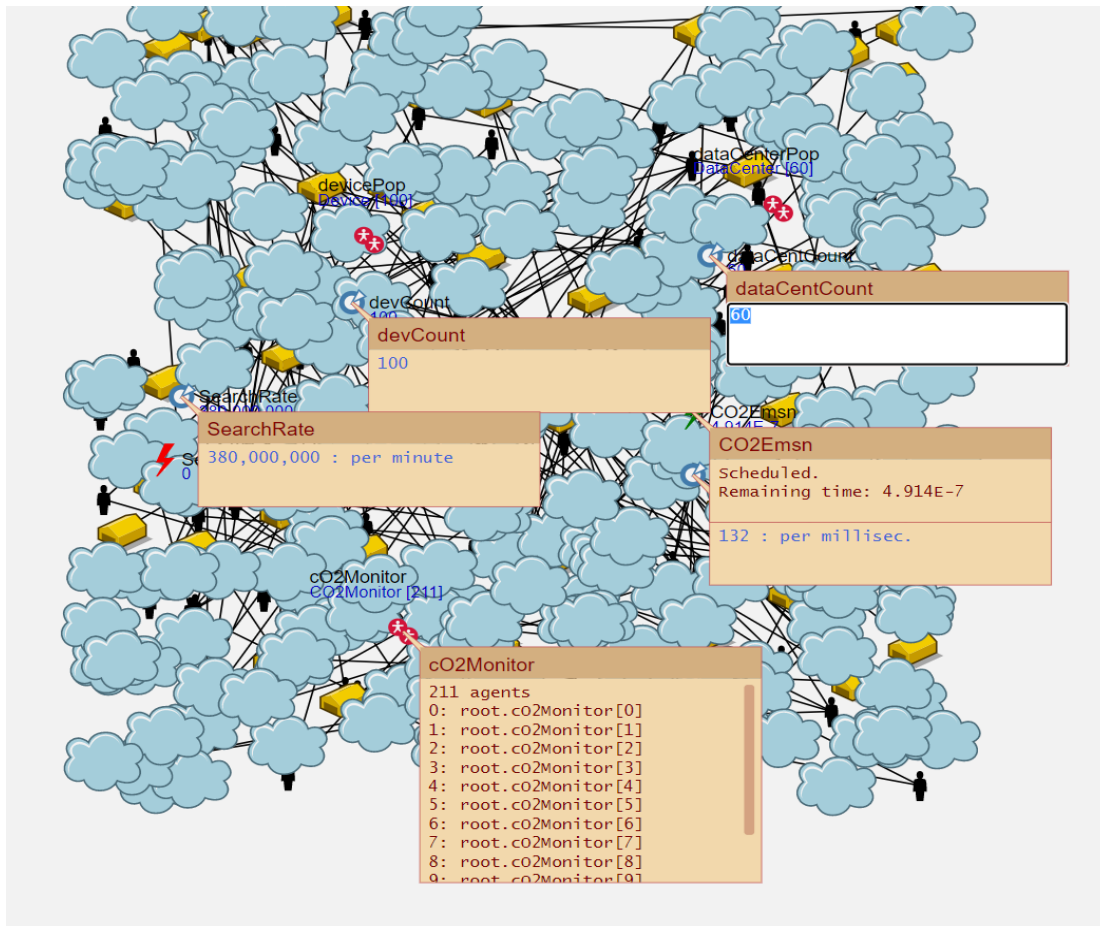


- As the number of searches increase the CO2 emissions increase, which inturn increase the number of CO2 clouds.
- Carbon emission rate also takes into account the number of data centers.

- During simulation I chose to keep the weight of number of searches higher as compared to the data centers as they more or less have an annual average consumption which is more or less similar.
- The increase in data centers is comparatively less with respect to the search requests sent.
- Also a part of energy used by Google data centers to function, comes from renewable resources, which reduces their role in CO2 emissions.
- Google search on devices can vary from high energy consuming to low but them using renewable energy resources is highly unlikely.



- AnyLogic allows us to monitor the values of parameters during runtime.



Conclusion

- AnyLogic is a software with more than a few numbers of layers wherein getting lost is extremely likely. It gives a lot of in-depth methods to work with but the how part of them is in a gray area. It can be taught as a course itself and still a few areas could be left untouched.
- As a beginner it would have been better to go with some topic for which it has a good library and quite a few examples and tutorials. Google search impact is a deep research topic because of umpteen factors playing part in it.
- There is a lot of scope in learning about both AnyLogic and the carbon footprint of Google search.

References

- [1] [How Much Energy Do Data Centers Really Use? - Energy Innovation: Policy and Technology](#)
- [2] [Alphabet \(Google\): energy consumption 2019 | Statista](#)
- [3] <https://qz.com/1267709/every-google-search-results-in-co2-emissions-this-real-time-dataviz-shows-how-much/>
- [4] <https://www.websitecarbon.com/how-does-it-work/>
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- [6] <https://www.youtube.com/user/NathanielOsgood/videos>
- [7] [AnyLogic Help | AnyLogic Help](#)