Modelling Climate Change Knowledge

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The Climate Change problem is one of most complicated target of research due to its cross-disciplinary nature, the multi-perspectives of stakeholders with conflicting concerns of interests and the quantity and complexity of the background knowledge required. Thus, to understand the Climate Change problem, one of the most important steps is to have a systematic way to analyze and manage the cross-disciplinary Climate Change knowledge with respect to the key stakeholders' interest.

As software researchers, one major role to play in this context is to provide software tool support to solve Climate Change related computational and engineering problems. Figure 1 depicts the Climate Change related computational and engineering problems in the different stages of Global Warming. From a computational aspect, the software research community can work to set the data exchange standard for Climate Change related software, and facilitate knowledge sharing and system integration at the application level. While for the engineering problems, such as GHG Mitigation and Climate Change Adaption, software researchers can also contribute to the solution designing and operation management in the engineering practices.

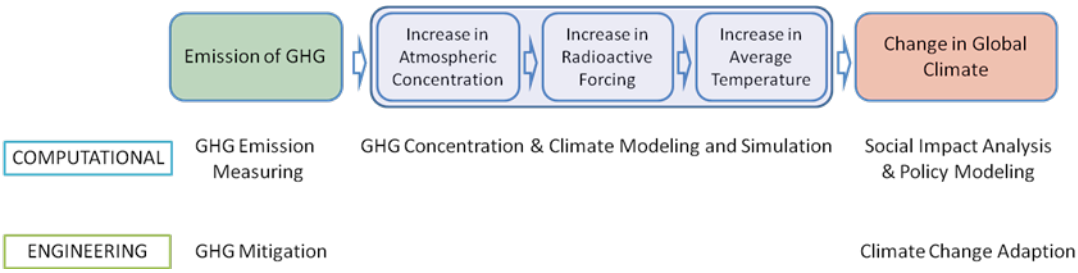

Figure 1 Computational and Engineering Problems Related to Climate Change
(Adapted from the Basic Elements of the Global Warming Problem figure [Robin, 2001])

In order to contribute to the two kinds of software related Climate Change problems, we first need to study about the different kinds of knowledge involved in the problems. Figure 2 gives a more specific view of the knowledge related to the Climate Change problems. There are three levels of Climate Change knowledge involved, namely the data level knowledge, the model and solution level knowledge, and the user goal level knowledge. On the data level, the major challenge is data collection and sharing. In addition, on the model and solution level, the biggest challenge is to integrate the interdisciplinary quantitative models to analyze the overall impact, and to design solutions according to the analysis results. Finally, different people may have different perspective on how to make use of the analytical results, and may need different mitigation and adaption solutions. On the user intention level, the challenge would be to satisfy the user's specific computational and engineering needs, and providing integrated user-specific service based on the user's own perspective.

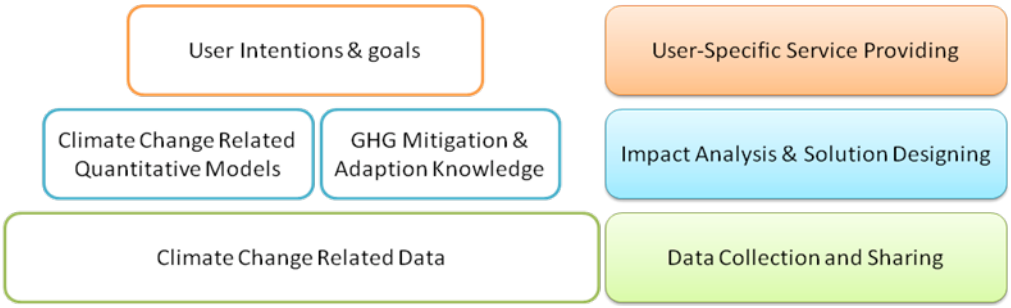

Figure 2 Major Kinds of Knowledge Related to Climate Change

1.1 Applying Object Model to Micro Level GHG Emission Analysis and Diagnosis

In respond to the data collection & sharing challenge and impact analysis & solution designing challenge, the object model can help carry out impact analysis and provide solutions on micro level.

Figure 3 explains the basic idea of building an object model for Climate Change related data and knowledge. As the Internet of Things being set up, it will become easier to collect information at the objects level. An object model could be built with the collected data and the GHG emission related attributes and functions. For a single object, the GHG emission data could be calculated from the object's original attributes and data from the online supporting database.

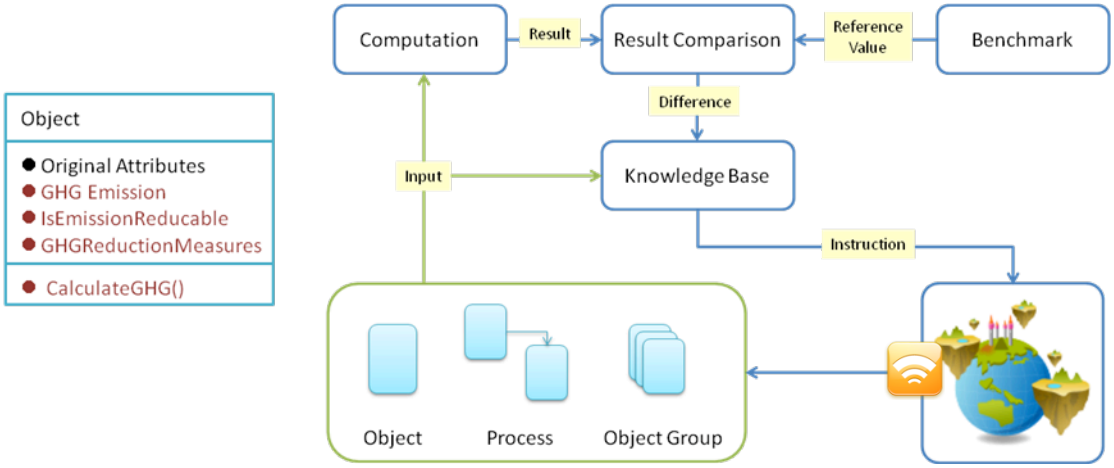

Figure 3 Object Model for Climate Change Related Data and Knowledge

The impact analysis can be carry out based on the individual objects or the processes and object groups abstracted from real world scenarios. The quantitative models will calculate the overall impact of the objects, processes and groups. With the calculation result comparing to the benchmark data, and with the original object model, diagnostic program can search for the specific GHG mitigation instructions from the knowledge. This object modelling approach is suitable for impact analysis and solution designing at micro level, such as individual carbon footprint calculation and project GHG mitigation analysis, etc.

1.2 Multi-Perspective Quantitative Models and Knowledge Integration

To provide user-specific Climate Change software and services, it is important to identify the users' own perspective towards the Climate Change problem, and to provide integrated services based on existing solutions.

Users usually have very different perspectives while looking at the climate change problems. For example, from an office building manager's point of view, reducing GHG emission to him usually means to reduce the total energy consumption of the building. But before he made energy savings plan, there are still a couple of concerns he may have in mind, like will the plan result in the decrease of inhabitants' comfort level and rising implementation cost? And if yes, how can he make trade-offs between these three factors. In contrast, an office worker inside the same building may only interested in reducing paper and energy consumption to reduce GHG emission at work without hurting his work efficiency. So from the examples, we could see that the perspective of a user could be identified by his specific Climate Change goals and the conflicting cross disciplinary goals.

Figure 4 illustrates our understanding to the user's perspective. As the goal decomposition shows, the Climate Change goal and other related top goals can be decomposed into sub-goals in several levels. For a specific user, some Climate Change goals along with some cross disciplinary goals can be selected according to his position. The selected goals and the trade-off relations between these goals could form the area of interest for the user.

Figure 4 Identifying the User's Area of Interest

To manage the quantitative models and the relevant knowledge, we could link the models and knowledge to the goals they supports. Based on the user's area of interest, model integration software support could be provided to generate an integrated model explaining the quantitative relations within the area. With the help of integrated models and the knowledge related to the goals, the user-specific service could be build according to the user's interest.

In summary, efficient software supports are important in solving computational and engineering problems related to the Climate Change. Modelling Climate Change knowledge is the foundation of these software supports. Modelling techniques from software research, such as, object modelling and multi-perspective modelling, could be applied in respond to the knowledge modelling and management challenges, provide good supports for impact analysis and diagnosis, and could help to generate user-specific software and services addressing the Climate Change problems.

Reference

[1] Rubin, E. and C. Davidson (2001). “Introduction to Engineering and the Environment”, McGraw-Hill.

[2] Easterbrook, S. and T. Johns (2009). "Engineering the Software for Understanding Climate Change." Computing in Science & Engineering 11: 64.

[3] Lin Liu, He Zhang, and Sheikh Iqbal Ahamed (2009). "Some Thoughts on Climate Change and Software Engineering Research", 1st WSCRCC, Onward!09.