



# Computational Modeling and Analysis of Adaptation and Long-Term Change in Inner Asia: Year 2



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## BACKGROUND

Project research objectives:

- To develop, test, and disseminate a new interdisciplinary theory of long-term societal change and adaptation to complex and evolving socio-natural environments, a "generative" theory formalized by a spatial multi-agent computational model;
- To contribute to the shared understanding of social complexity across the social sciences by integrating concepts and principles within the proposed theoretical framework and research methodology;
- To produce and disseminate new interdisciplinary data resources created by this project, such as a new long-term dataset and diachronic atlas of Inner Asian polities.

## YEAR TWO DEVELOPMENTS

Since our last report in December, 2007, we have marked progress by developing:

- A new chronology for Inner Asia (systematic periodization did not exist prior to this project);
- An original data set of polities for the region of interest;
- Agent-based models (ABMs) that form the basis for further development and cross-level integration as we complete the project to meet our goals.

Dissemination has taken place via publications and conference papers (see References).

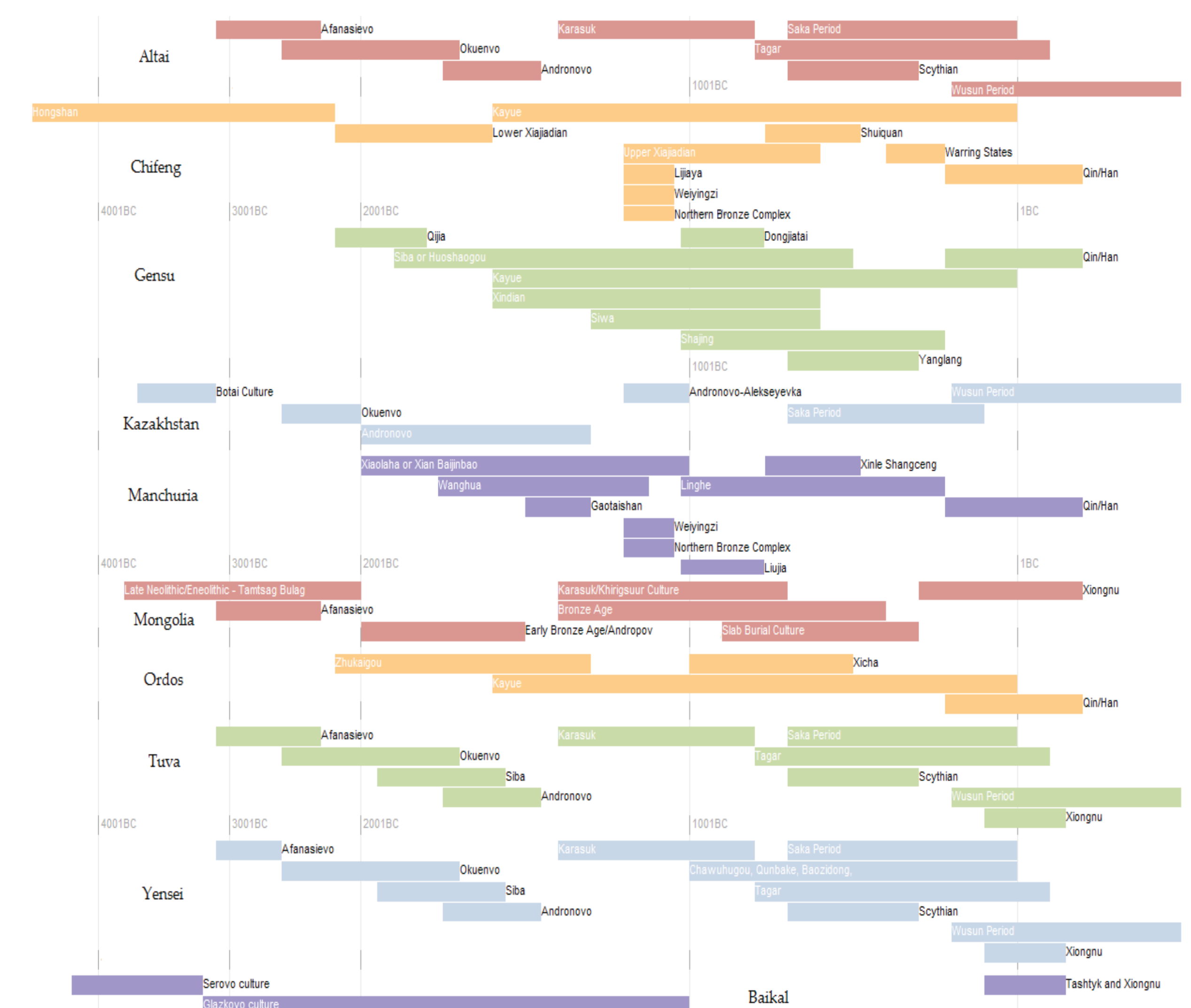
## NEW AGENT-BASED MODELS

Two MASON ABMs have been created on different spatial and time scales (see below):

- Households ABM:** This lowest level models the subsistence economy of nomadic societies. The Households ABM is spatially and temporally explicit and is initialized using GIS information. This model is intended to represent herding patterns and behaviors of members of a single clan composed of households.
- Hierarchies ABM:** This next level models political interactions among clans, aiming to replicate patterns of collapse and emergence of nomadic confederations prior to the Hünnu (Xiongnu) epoch.

Currently, we are integrating both models to create a hybrid model spanning five orders of complexity (Household to Camp to Clan to Confederation to World System).

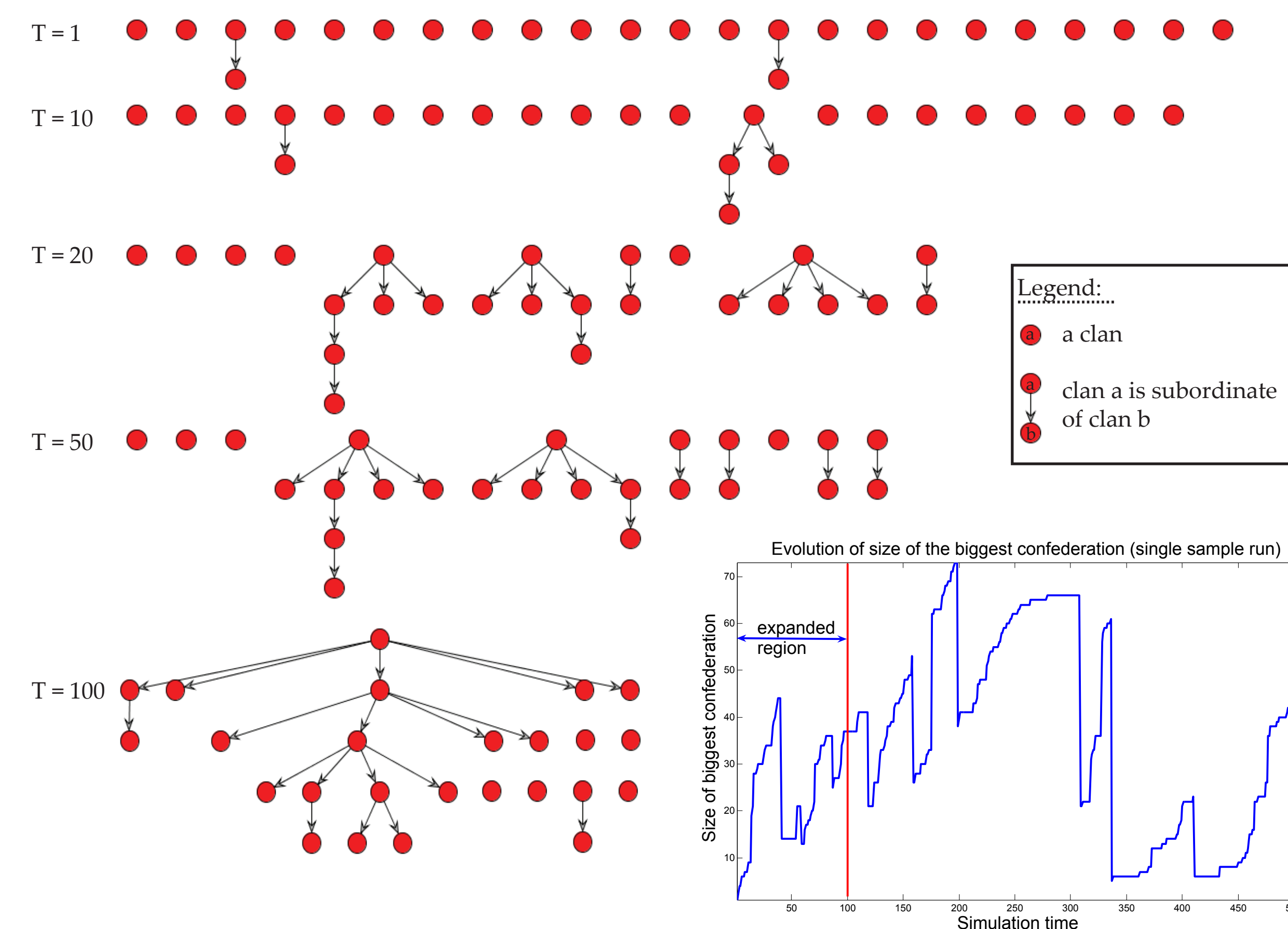
## SOCIETIES AND NEW CHROLOGIES OF THE INNER ASIA



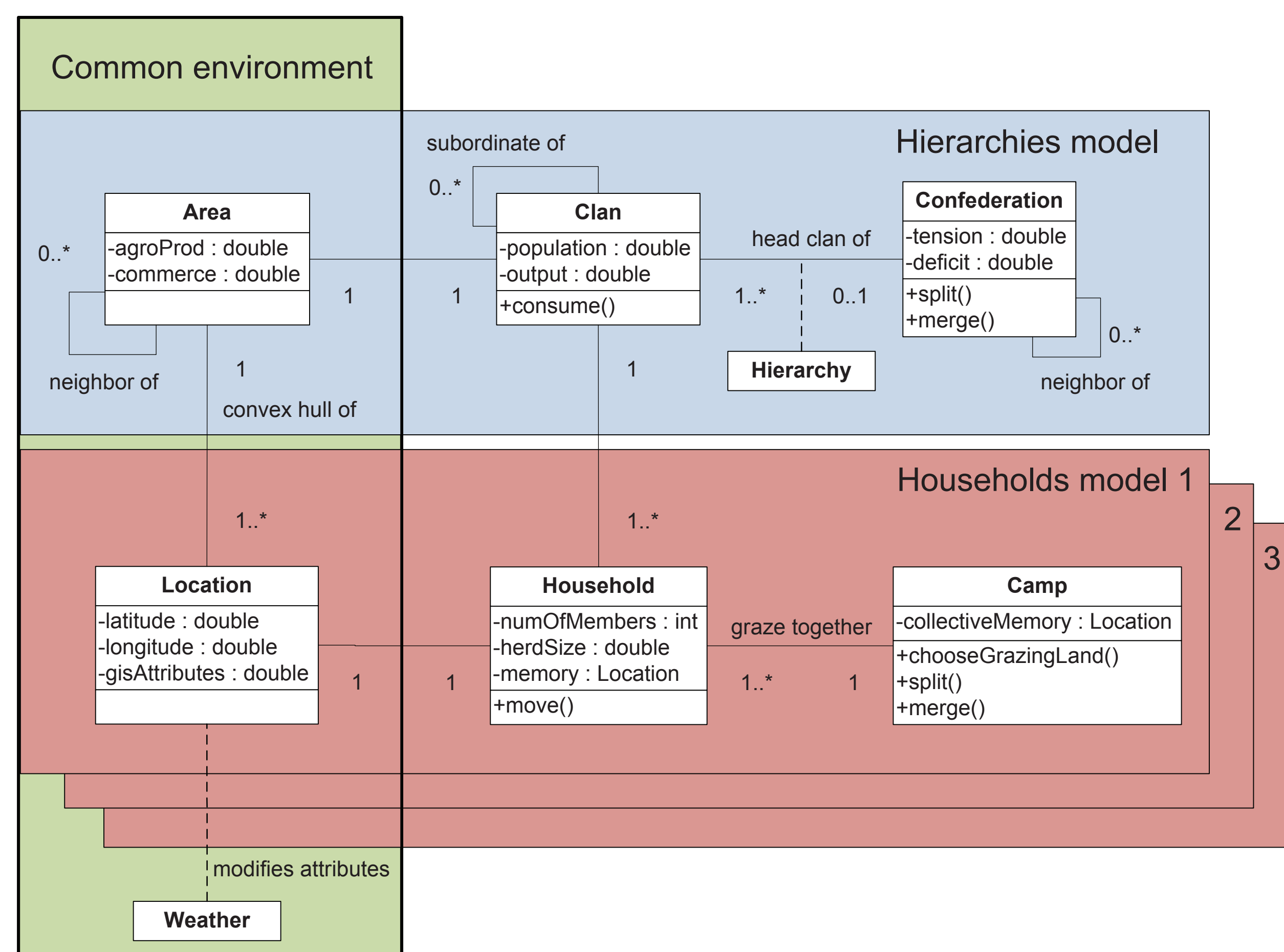
This periodization of Inner Asia is the first of its kind and was compiled from numerous sources (archaeological, epigraphic, historical) by Smithsonian members (Honeychurch and Rogers). Mason members produced this version (Cioffi and Latek) using SIMILE Timelln..

## MODEL HIGHLIGHT

The Hierarchies ABM produces a wide range of outputs. In particular it is possible to trace the evolution and distributions of confederation sizes and conflicts. The MASON facilities allow for experimenting with different scenarios when the world system undergoes different exogenous (environmental) as well as endogenous (death of leader) shocks. A sample run is presented below.



Output from a single run of the Hierarchies model. We show the evolution of the size of the biggest nomadic confederation. The five snapshots of hierarchies of all confederations represent the complete range of complexity present at a given time.



UML class diagram showing key components of our ABMs and the docking points for embedding multiple instances of the Households model inside the Hierarchies model.

## PROJECT PUBLICATIONS

Cioffi-Revilla, C., S. Luke, D. C. Parker, J. D. Rogers, W. W. Fitzhugh, W. Honeychurch, B. Frohlich, P. DePriest, C. Amartuvshin. 2007. Agent-based Modeling Simulation of Social Adaptation and Long-Term Change in Inner Asia. In *Advancing Social Simulation: The First World Congress in Social Simulation*. Tokyo, New York, Heidelberg: Springer. Pp. 189-200.

Cioffi-Revilla, C. 2007. Polychart Analysis in Human and Social Dynamics. Paper presented at Annual Meeting of the Association of American Geographers, San Francisco, CA, April 17-21.

M. Latek, M. Tsvetovat, W. Honeychurch, and C. Cioffi-Revilla. 2007. Computational Empires: Hierarchies, Power and Warfare in Ancient Inner Asia. Paper presented at the Annual Conference of the NAACOS, Atlanta, Georgia, USA, June 7-9.

Latek, M. 2007a-b. Jung 2 Extensions to MASON 12.0; and GeoTools Extension to MASON 12.0. MASON Project, [cs.gmu.edu/~eclab/projects/mason/#Extensions](http://cs.gmu.edu/~eclab/projects/mason/#Extensions)

Rogers, J. D. 2007. The Contingencies of State Formation in Eastern Inner Asia. *Asian Perspectives* 46 (2):249-274.

Rogers, J. D. and C. Cioffi-Revilla. 2007. Expanding Empires and the Analysis of Change. First International Conference on Archaeological Research in Mongolia, Ulaan Baatar, August 19-23.

S. Luke, et al. 2007. MASON 12; and ECJ 16. MASON Project, George Mason University, Fairfax, VA. <http://cs.gmu.edu/~eclab/projects/mason/>.

S. Luke, D. Sharma, and G. Catalin Balan. 2007. Finding Interesting Things: Population-based Adaptive Parameter Sweeping. In *GECCO 2007*. Association for Computing Machinery.

## ACKNOWLEDGEMENTS

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