BioWar is a city-scale simulation of the effects of biological attacks on an American city, with the resident population of agents modeled at the level of individuals. The heterogeneous agent pool varies in age, race, gender, occupation and connects to other agents through individual social networks and physical proximity. BioWar models the impact of background diseases, natural disease outbreaks and bioterrorism attacks on agents. Based on their individual health status, agents go about their normal daily routine or seek medical treatment, generating health data, absenteeism reports and other statistics. As agents interact with each other, their interaction may allow the further spread of infectious diseases. The simulated cities are modeled using real data from selected metropolitan areas, including population demographics, economic census information, school district and census tract boundaries, climatic data and medical resources.

A wide variety of output reports are generated based on user needs, including absenteeism patterns, pharmaceutical purchases, doctor's office insurance claims, and hospital/emergency room reports. Special reports are available for specific sentinel groups including military personnel, first responders and health workers. Output matching the format of real world data streams and reports can be created for analysts or public health personnel, including appropriate lags in delivering data. For computational efficiency, cities can be simulated at reduced physical scale or with a smaller population.

BioWar has been used to model the effects of attacks using anthrax, smallpox and other biological agents. The simulator is able to generate mortality results comparable to incidents in Sverdlovsk, Russia and Washington, DC in the United States as well as various smallpox reference outbreaks. BioWar has been used to generate data for testing attack detection algorithms and to examine various response policies and mitigation strategies.

BioWar is actively being enhanced for interactive operation, chemical attacks and to add more detailed first response capabilities, including crisis response.

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<BioWar Tech Report: CMU-ISRI-04-101>

BioWar is scalable city-wide simulation, capable of simultaneously simulating the impact of background diseases, natural outbreaks and bioterrorism attacks on the population's behavior within a city. The multi-agent simulator includes social and institutional networks, weather and climate conditions, and the physical, economical, technological, communication, health, and governmental infrastructures which modulate disease outbreaks and individual behavior. Individual behaviors include health seeking, entertainment and work/school behavior. A wide variety of reports are generated based on user needs including absenteeism patterns, pharmaceutical purchases, doctor's office insurance claims reports, and hospital/emergency room reports. Sub-reports are available for specific sentinel groups including military personnel, first responders and health workers. Reports matching real world data streams and reports can be created for analyst or public health personnel including appropriate delays in generating said reports. This paper provides an overview of BioWar's current capabilities and information on the algorithms and data used to drive the simulation as of the Challenge 5 (C5) version.

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<Existing BioWar web page as of 6/13/05:
http://www.casos.cs.cmu.edu/projects/biowar/index.html>

In trying to prepare for attacks, policy makers need to be able to think through the consequences of their decisions in various situations. Consider, for example, trying to decide if all US citizens should be vaccinated for smallpox. Speculations abound as to the potential devastation that smallpox could wreak. Medical experts, scientists, and policy makers need a way of thinking through the morass of complex interconnections to understand whether different inoculation or containment strategies will be effective. Unfortunately many existing models are quite limited in that they only apply to a single disease, discount factors such as the urban geography which can influence disease spread, or discount how people use their social networks (who is friends with whom) to pass information such as when to go to the doctor to be treated. In general, being able to estimating the impacts of large scale biological attacks and the efficacy of containment policies is necessary from an intelligence and planning perspective and requires reasoning about social response and disease processes as a complex social system.

In BioWar we are combining state-of-the-art computational models of social networks, communication media, disease models, demographically accurate agent models, wind dispersion models, and a diagnostic error model into a single integrated model of the impact of an attack on a city. Unlike traditional models that look at hypothetical cities, in BioWar the analyst can examine real cities using census, school track, and other publicly available information. Moreover, rather than just providing information on the number of infections, BioWar models the agents as they go about their lives - both the healthy and the infected. This enables the analyst to observe the repercussions of various attacks and containment policies on factors such as absenteeism, medical web hits, medical phone

calls, insurance claims, death rate, and over the counter pharmacy purchases. BioWar moves beyond existing epidemiological models that do not consider the heterogeneity of social networks and the geographical distribution of people when predicting disease outbreaks.

BioWar is an effort to develop a scaleable and precise simulation tool to examine disease propagation and agent behavior in response to disease and illness. We believe it will serve to help researchers understand, predict, and analyze weaponized biological attacks at the city level and engage in "what-if" analyses to help inform decision-making in this complex socio-technical policy domain. For example, it can be used in a "what-if" mode to examine the impact of and response to various weaponized attacks for contagious and non-contagious diseases under high-alert and no-alert conditions.

Version 2.1 has been tested on 3 cities, can handle 2.5 million agents and 2 years of interactions in 1 day of processing on a 4 processor system, and contains models of 60 diseases. Core modules include: City Generation, Social Network Generation, Agent Behavior, Disease (Transmission, Progression and Diagnosis), Weather (wind and climate), Attack Generation, Aerosolized Dispersion. Actual census, geographic, and behavioral information used as inputs. Outputs designed to reflect actual data streams for absenteeism, ER and Dr visits, OTC purchases, etc..

Version 2.2 had been optimized and tested on 5 cities.