# Agent-based modeling and approximation for *Toxoplasma gondii* transmission dynamics in a virtual farm

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Toxoplasma gondii (*T. gondii*) is a common eukaryotic parasite, which can be transmitted to humans via contaminated food and water, or undercooked meat products. Up to 10% of the human population in the US and 30% in the world are chronically infected. In some regions, the prevalence can be as high as 80%. Although infection of immunocompetent people is mostly asymptomatic, the latent feature of Toxoplasmosis is a hidden danger to human health. For example, infections in humans can cause life-threatening encephalitis in immunocompromised persons such as

Figure 1: sketch of an agent-based model for Toxoplasma in a virtual farm.

AIDS patients, recipients of organ transplant and cancer chemotherapy. In addition, infection acquired during pregnancy may spread and cause severe damage to the fetus.
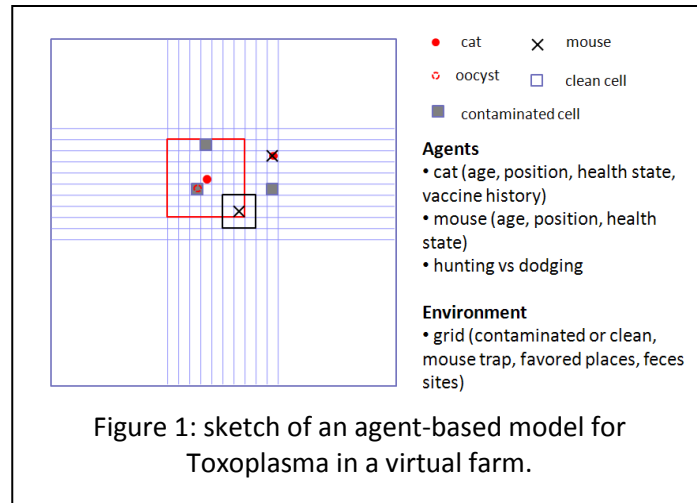
We develop an agent-based model to describe the complex life cycle of *T. gondii* in a virtual farm. Here, an infected cat may cast feces containing oocysts of *T. gondii* to the environment. If a mouse comes into contact with an area that is contaminated with oocysts, it may ingest the oocysts and get infected. Then, a cat, ingesting the tissue cysts of an infected mouse, may become infected. A cat may also get infected from oocysts in the environment but with a much lower probability. In addition, the vertical transmission from the infected mice to their offspring is another possible route of transmission of *T. gondii*. All of the above mentioned transmission behaviors are assumed to occur with certain probabilities. For simplicity, we assume cats and mice do not migrate to and from the

Figure 2: The average cat number over 100 simulations using ABM (red) and CTMC approximation (blue).

farm. Numerical simulations are carried out to study the efficiencies of various transmission strategies and to understand the influences of parameters. To facilitate analytical understanding on transmission strategies of *T. gondii*, we develop a spatiotemporal continuous time Markov chain model to approximate the population level dynamics of the ABM. Preliminary studies using a simplified dynamics framework show that the Markov chain model can accurately approximate its agent-based counterpart.