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# Games, Social Simulations, and Data—Integration for Policy Decisions: The SUDAN Game

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## Abstract

In this article, the authors discuss the development of the SUDAN GAME, an interactive model of the country in the time period leading up to the Sudanese referendum on the secession of the South. While many simulations are designed to educate about their subjects, the SUDAN GAME is intended to be a prototype for policy making via gameplay. It is implemented within COSMOPOLIS, a massively multiplayer online game that is currently undergoing development. In this article, the authors discuss the game's design and how it can be used for policy development, with a focus on the underlying model and some discussion of the COSMOPOLIS implementation. They situate the game relative to other games that have crowdsourced serious problems and discuss the meaning of the policy solutions and collaboration witnessed along players. They conclude with a discussion of future development to be done to improve and expand upon the concepts used in their game.

## Keywords

avatar-based game, computer simulation, constraint, crowdsourcing, game design, gameplay, interactive model, intertribal tension, massively multiplayer online game, networks, policy development, policy making, prototype, prototypical model, state instability, Sudan, underlying model, video games

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Social simulation is an important tool for understanding the ramifications and outcomes of complex events. It is underpinned by the idea that by developing an understanding of a situation, operationalizing a set of hypotheses derived from this understanding, and then propagating the consequences of these hypotheses, we can see their ramifications. (Knowing their implied ramifications does not validate these hypotheses, though it may inform our opinion of them.) Simulations have classically been used to provide useful perspectives on racism (Vandell & Harrison, 1978), disease outbreaks (Carley et al., 2006), cooperation in uncertain circumstances (Axelrod, 1987), and many other scenarios.

Simulations are designed to provide the maximum amount of detail that is both necessary for the model's particular purpose and that can be reasonably computed. The latter caveat is a key constraint on simulation detail. Designing to constraints can result in an unfortunate sacrifice of resolution, and has inspired researchers to develop innovative methods for increasing simulations' power such as leveraging computers' graphics cards for additional speed (Bonabeau, 2002; Maxwell & Carley, 2009).

To address this issue, we take a cue from the crowdsourcing methods used by von Ahn and Dabbish (2004) and Cooper, Treuille, et al. (2010). We incorporate the model into a game so that it can be presented to humans, who will heuristically try and solve it. (That is, beat the game.) We rely on humans' ability to evaluate available data such that, when presented with a choice, they will try and make the best decision possible. We hypothesize that, by presenting players with an interactive model that explains its properties, the players will be able to come up with optimal solutions for social models in the same way that they can develop unique and optimal solutions to issues such as protein folding (Cooper, Khatib, et al., 2010). Sequences of decisions generated by users responding to the model as it iterates over time, when tested to ensure their validity over multiple replications, can be considered complete solutions to the model. Most significantly, finding these solutions will be significantly simpler than testing the complete solution space of the model.

In this article, we discuss our implementation of a prototypical model of intertribal tension in the Sudan, as well as its implementation as an avatar-based game (the SUDAN GAME). In this model, tribe members interact to learn new facts about a set of key beliefs. As tribe members' beliefs diverge or converge, Sudan becomes decreasingly or increasingly stable. Players can intervene to increase particular portions of Sudan's population's knowledge of different issues, thus increasing the country's stability. The SUDAN GAME is interesting both because it is based around a current, real-world political issue, and also because it represents a class of policy games associated with state instability in two-group states.

We built our model using the CONSTRUCT agent- and dynamic-network-based modeling system, in which a variety of validated social models have been built (Carley, 1990, 1991; Center for the Analysis of Social and Organizational Systems, 2010; Schreiber & Carley, 2004, 2007). CONSTRUCT models human agents as knowing discrete facts, holding discreet beliefs, and interacting over discrete time periods. With each interaction, agents convey facts and beliefs to each other. Facts

can be oriented to positively or negatively influence a particular belief. Agents favor interacting with other agents with whom they share particular traits, where appropriate traits can be determined on a simulation-by-simulation basis. We describe the specifics of the model we have built for Sudan in the “Method” section.

We use validated input data in the form of text from the *Sudan Tribune*, from which tribal relationships have been extracted and then validated by Sudan subject matter experts (SMEs; Carley, personal communication, July 26, 2010; Van-Holt & Johnson, 2011). These relationships are represented numerically, with 0 indicating no relationship and 1 indicating a maximum relationship. A relationship is considered neither positive nor negative—It only indicates that the tribes are often described in the same context in different news articles. The *Sudan Tribune* is an online English-language newspaper, based in Paris. It “promote[s] plural information, democratic and free debate on Sudan” (Sudan Tribune: Plural News and Views on Sudan, 2012). It is aimed at expatriates and can be thought of as having a modest bias against the established government.

While the source data for our model have been validated, we lack data to similarly validate the model’s output. An appropriate validation method would be to compare the current state of Sudan and South Sudan with the model’s output for the current state of relationships between the nations when input with an appropriate docking of the prereferendum events that occurred in the former Sudan.

The model postulates a relationship between a particular set of beliefs held by tribe members and growing tensions in the populace. It considers these beliefs correlated with tribal affiliation. While each fact in the model is exclusively related to one belief, each agent in the model has a unique set of biases for and against particular facts, calculated as a function of its tribe. We find evidence for this idea in research on the country, our intuition (D. H. Johnson, 2006), and in the confirmation that these beliefs exist and are significant by our SME.

The model incorporates two different types of interventions on knowledge: directly appealing to tribe members or the national populace, and carrying out a forum of different tribal leaders. A total of 20 different actors, representing tribal and national leaders, can carry out these interventions. At any one time period, 185,760 possible interventions are possible. This large count makes it infeasible to rigorously test all combinations of interventions.

While the model cannot be completely solved by conventional methods, we have probed it using several tests in order to more fully understand the solution space in which players will function during the game. This response surface gives us a sense of the range of solutions achievable by players.

The SUDAN GAME is implemented within COSMOPOLIS, a massively multi-player online (MMO) game currently under development (GamePipe Laboratory, 2011). It leverages COSMOPOLIS’s avatar-based design for player interaction with the model and to provide them with a sense of Sudan. Because of this embedding, the SUDAN GAME will not be released until COSMOPOLIS is available.

In the following section, we review the salient game and simulation literatures in which we situate the SUDAN GAME. In the “Method” section, we review the implemented model in further detail, our probing of it, and its implementation in COSMOPOLIS. We conclude with a discussion of our expected findings and future work to be carried out.

## **Situating the SUDAN GAME**

We consider our combination of simulation of a real policy challenge (peace in the Sudan) and its integration into an MMO game to leverage the choices of the crowd to be at the center of several literatures. These literatures build from a conception of simulations as existing for both utility and entertainment, of games as both simulations and as methods of encouraging participation within a defined framework, and of the utility of combining the work of many individuals to understand a single, optimal solution.

The first literature we reference is that of simulations that are intended for entertainment, but also have a practical function. Commercial games such as SIMCITY and PEACEMAKER, while sold to the mass market as entertainment, are also educational simulations that teach their own orthodoxies (Burak, Keylor, & Sweeney, 2005; ImpactGames, 2007; Maxis, 1993). SIMCITY has also been used as a predictive tool (Peschon, Isaksen, & Tyler, 1996), and the engine behind the commercial Role-Playing Game NEVERWINTER NIGHTS has been adapted for use for training scenarios and experiments on cultural and economic values (Castronova, 2008; Leung, Diller, & Ferguson, 2005; Warren & Sutton, 2008). Military simulations have likewise danced along the fine line separating the practical and the entertaining ever since their advent. The German war game KRIEGSPIEL was intended solely for military education, while H. G. Wells (1913) described his LITTLE WARS as entertainment. More recently, the military has worked with industry to create games that coexist as entertainment, recruiting tools, and training programs (Smith, 2010). Contrasting with these prosimulation views, Clinton’s policy advisor Paul Starr has expressed reservations about the rigidity of using entertainment simulations for teaching. He is concerned that their absolute rules crystallize policy binaries, causing users to close off legitimate avenues of inquiry. (SIMCITY’s lack of support for mixed-use buildings in residential zones should not be construed as proof that mixed-use buildings cannot exist; Starr, 1994.)

The second literature against which we situate our work is that of interpreting players’ activities in games to better understand reality. This would include the recent blossoming of interest in trying to find parallels between data harvested from MMO games and reality (Castronova et al., 2009; N. F. Johnson et al., 2009). Castronova and Falk (2009) made the case for constructing stable virtual worlds in which to measure these effects. Williams (2010) provided a thorough review of extant work and concerns with “mapping” from the virtual to the real in experimental contexts, as well as recommending particular research designs.

Corresponding with this academic interest, game designers have also noted the potential for players to address real-world issues, with early work focusing on Alternate Reality Games (ARGs; McGonigal, 2003). ARGs create the illusion of an alternate reality situated within the real world. They are games that often designed to play out over weeks or months, and frequently incorporate transmedia content (e.g., hidden USB drives, secret web pages, fake emails, and calls to pay phones). One player cannot complete an ARG alone. The diversity and difficulty of the game's puzzles and the distances between different game locations demand collaboration between many players.

Because of their open-endedness and complexity, ARGs can be viewed as complements to many of today's global problems. Work stemming from ARGs has focused on getting players to collaborate in order to develop new solutions to problems.

EVOKE, an ARG in which players investigated and then attempted to conceptualize practical solutions to high-level global problems, is prototypical of this work; a subset of the developed solutions was submitted for funding as part of a World Bank-sponsored competition (McGonigal, 2010a, 2010b; Sutter, 2010). EVOKE uses the trappings of fiction to define a game world: Players are part of a secret team that addresses widespread global challenges. The tasks that players carried out are conventional; some players conducted background research, others proposed solutions, and others vetted and commented on those solutions. More recently, the Naval Postgraduate School has tested Massively Multiplayer Online Wargame Leveraging the Internet (MMOWGLI), an ARG framework that does not propose any kind of narrative within the game itself (Jensen, 2011; Naval Postgraduate School & Institute for the Future, 2011). MMOWGLI tries to optimize knowledge creation for any chosen problem via a set of mechanics and a usable web interface. These tasks are similar to those of EVOKE, but are primarily intended to encourage discussion and vetting of proposed ideas. MMOWGLI is an attempt at systematizing and regularizing the ARG method.

The final literature to which we connect our work is that of crowdsourcing data analysis through play. In the computer science community, games and simulations have been used as tools for accomplishing computationally difficult tasks. Traditionally, crowdsourcing is accomplished through platforms such as MECHANICAL TURK, where workers are hired at low wages to carry out simple tasks (Amazon.com, 2005). Games provide an alternative to paying, where workers are instead rewarded through fun. This can potentially increase workers' investment in a problem and providing better, more intelligent results. Cooper, Treuille, et al. (2010) described such entertainment as "Scientific Discovery Games" and have demonstrated success with FOLDIT, in which players compete to fold proteins (Cooper, Khatib, et al., 2010). von Ahn and Dabbish (2004) pioneered much of this work in the computer science community with their development of the ESP GAME, which induces players to develop useful tags for images, and have coined the term *Games With a Purpose* (GWAP) to describe this class of entertainment. A variety of similar games have been developed by other researchers to address issues such as aggregating objects into related collections or solving satisfiability problems (DeOrio &

Bertacco, 2009; Walsh & Golbeck, 2010). While simple, the GWAP approach risks error due to user bias. Dong and Fu (2010) demonstrated that elements of cultural bias can skew image tagging practices such that the produced tags are primarily relevant to the cultural group from which the taggers have been drawn.

We can think of GWAP, Scientific Discovery Games, and ARGs as substituting a human element into the system to serve as a black box problem solver. This box comprises those elements of the system that cannot be adequately modeled digitally. In this framing, ARGs assume that problems cannot be simplified and so use humans to address all of their aspects. A round of MMOWGLI, for example, presents humans with a large problem and encourages them to interact and discuss the problem repeatedly in order to develop a proposed workable solution for it.

In contrast, GWAPs place the player in a box that contains only one or two very simple tasks. Often, the players create the correct solution to the problem. When a player tags a photograph, if he or she is working honestly the tag will be useful. (It is people who determine how something should be correctly labeled.) Provided that a few players reanalyze the same data and outliers are trimmed, the results will be correct.

Scientific Discovery Games use boxes larger than those of GWAPs, but markedly smaller than those of ARGs. Users are not necessarily working directly on data that will produce correct results, but rather with models of more complicated phenomena. When FOLDIT's players manipulate protein strands, they are manipulating models of well-understood larger systems. As such, there is a potential for users to generate bad results if the underlying model is flawed or if the game presents the model in a way that is hard for players to understand. In the case of a social game, such as ours, there is a potential that underlying player biases will prejudice them against creating good solutions (Kuperman, 2010).

The game should simplify the representation of the model as much as possible so that the player only needs to concern themselves with its essential components. Simplification to a situation creates a corresponding risk of oversimplification that must be assessed by the modeler. An overly simplified or biased model can easily induce player to give bad results, as noted by Starr (1994) with his concern over the lack of mixed-use development in SIMCITY. Players must feel that they have enough information to actually make a decision about the social problem, but all extra fat must be trimmed away.

We propose to consider this limited use of the black box for social simulation. Instead of asking humans to analyze the world through a fictional lens, as in an ARG, we ask them to analyze a model scenario developed in accordance with SME knowledge. (One could substitute *SME* with *game designer* and *model scenario* with *simulation game*, as in SIMCITY.) By presenting this simulation to a mass of unskilled players, we will develop a number of possible sequences of interventions that can be applied to Sudan. While many of the players' attempted solutions will be unsuccessful, those that succeed will be worth further analysis in simulation and possibly subsequent application to the real situation from which the scenario has been derived.

## Modeling Sudan

Until 2011, Sudan was a northeast African country with a history of North–South tension that has twice erupted in civil war. The causes of this stress are difficult to determine, but date back to at least Islam’s arrival in the region and were sustained, if not cultivated, by British governance policies. Contributing factors may include religion (the North is majority Muslim, the South favors animism and Christianity), resource issues (mineral and oil wealth is concentrated in the South, but processing capabilities have chiefly been developed in the North), land use issues (nomadic Arabic groups in the North and African farmers in the South), ethnic and linguistic differences (the North uses Arabic and English and the South uses English, Dinka, Nuer, and several other ethnic-linguistic groups), and intertribal tensions (D. H. Johnson, 2006). Over 100 tribal groups coexist in the Sudan in varying degrees of amity and hostility with a larger number of tribes in the South than in the North.

The most recent civil war ended in 2005 with the Comprehensive Peace Agreement (CPA). Under its terms, Sudan remained one nation with the South functioning as a separate federal unit from the North. A referendum was to be held 5 years after the treaty, during which the South could vote to secede from the country if it felt the unification had been unsuccessful.

During the period between the peace agreement and referendum, the tensions between the regions went unresolved. The North’s failure to develop the infrastructure of the South, concern over legal representation, and mineral and oil rights remained open issues. Expert predictions generally held that the South would secede (Block, 2010; International Crisis Group, 2007, 2010). When the referendum vote took place on January 9, 2011, the South voted overwhelmingly for secession (Kron & Gettleman, 2011). The two countries are currently in the process of divorce, with the Republic of South Sudan having officially come into existence on July 9, 2011. Following South Sudan’s secession, the remaining country officially remained the Republic of the Sudan, herein referred to as Sudan or the North when necessary for identification. The consequences of separation are not fully known, but are anticipated to have serious ramifications on the world stage given the presence of oil reserves in the South. National and tribal relationships are still fraught due to oil disputes, the transnational migration routes of many nomadic Sudanese tribes, repatriation of (mostly South) Sudanese, and internal revolts in both Sudans (Gettleman, 2011; International Crisis Group, 2011a, 2011b, 2011c; Laessing & Abdelaziz, 2012; Sudan Tribune, 2012).

### *The Model*

Our model of Sudan is retrospective; it is built using data from before the referendum and intended to simulate the impact of different actions by leaders leading up to the referendum. It is intended to be accurate, but this accuracy is secondary to our goal of prototyping an interactive belief model based around sequential interventions. Our

model is built on the general principle that particular core *beliefs*—propositions regarding the nature of the world—dictate individuals' general actions. An individual's beliefs are formed by a combination of biases they possess and facts to which they have been exposed. Bias can be considered the substrate of initial beliefs possessed at the start of the model. As the model runs, individuals expose each other to different facts and thus evolve their beliefs. (Our system's use of the terms *fact* and *belief* is agnostic to the truth of either, and these roles can be altered across different models. "The moon landing was faked" could be a belief that an agent forms, based on exposure to particular facts in one model, and a fact—despite being incorrect—in another.)

In the case of Sudan, we construe the central set of beliefs to model to be those contributing to tensions between the tribes in North and South Sudan. We assume that, had the tribes in the two halves of the country agreed on a central set of core beliefs, the outcome of the referendum (resulting in separation or not) would not have brought on the intertribal conflict that currently afflicts it. (It is worth noting that the CPA's language referred to the idea of "making unity attractive" and the idealistic desire underpinning it that common ground between the different tribes can be found.) For example, if all of the tribes of Sudan had held it important that Sudan remain unified, tribe members would have worked to maintain national unity. In contrast, if they had held it unimportant that Sudan remain unified, the country's split would have caused minimal distress.

Discord occurs when different groups have strongly conflicting attitudes toward a belief. These belief differences—and the hostility they create—are often seen as a function of tribal, regional, and material differences. (For example, the Arabic tribes of the North have beliefs shaped by having been nomadic Muslims, while those in the South by being Christian and animist farmers and pastoralists. The bulk of Sudan's oil is concentrated in the South, but must be sent through the North.) These hostilities can be seen in attitudes toward human and women's rights, with northern tribes abducting southern children, targeting southern women for human trafficking, and enslaving Dinka women and children (U.S. Department of State, 2009).

Our model was built using CONSTRUCT, a language and engine for carrying out multiagent social simulations of knowledge and belief propagation. CONSTRUCT has been used to simulate various real-world situations (Carley, 1990; Schreiber, Singh, & Carley, 2004). It is conceived around the idea that human agents interact in a turn-based fashion, exchanging discrete facts that are slanted toward particular beliefs. CONSTRUCT takes into account the idea of homophily by having the particular features shared by agents (such as tribe) increase the probability that a pair of agents will interact. This probability will trend upward or downward over time as agents gain similar or different facts. Agents thus grow together or apart over time. Our model has been primed with a set of tribal relationships extracted from the corpus of the Sudan Tribune from 2003 through 2008, as well as a set of tribal-relationship networks based on historical information and vetted by SMEs. The networks were extracted from the Sudan Tribune corpus using a mix of hand-coding and semiautomated extraction techniques in AUTOMAP (Center for the Analysis of Social and Organizational Systems,

**Table 1.** Tribes Used in the Model and Their Corresponding Agent Counts

Southern tribes	Agents	Northern tribes	Agents
Acholi	6	Misseriya	50
Anuak	8	Rizeigat	29
Bari	49	Seleim	5
Bor Dinka	27		
Gok Dinka	27		
Malual Dinka	27		
Ngok Dinka	27		
Madi	2		
Mondari	16		
Murle	13		
Nuer	104		

2011). The extraction of these networks is beyond the scope of this project; see Van-Holt and Johnson (2011) for additional information. For this project, we constrain the extracted networks to only include tribal relationships, and constrain the set of tribes to the 14 with the strongest relationships. In all, 11 are taken from the South and 3 from the North. We derived membership counts for each tribe from information on Sudan collected in the *Central Intelligence Agency (CIA) World Factbook* and The Joshua Project, which catalogs ethnic people for religious conversion (Central Intelligence Agency, 2010; The Joshua Project, 2010). Using the full counts of agents for each tribe made the project computationally infeasible. In response, we reduced the population of each tribe by a factor of 10,000, leaving a total of 390 agents across the tribes (see Table 1).

This is a limited representation of the country’s population. However, our Sudan Tribune data contains relatively few strong relationships, and to include numerous trivial relationships would make the game confusing to play. By using the best-connected tribes, we consider ourselves to be looking at the relationships that can be most readily dealt with and that will play the most significant roles in the country’s stability.

Members of each tribe are connected based on the aforementioned historical and news networks. Connection values are calculated for each agent as a function of their tribe, and CONSTRUCT regulates the probabilities of two agents interacting accordingly. For example, the data links the four Dinka tribes together most closely, then the other southern tribes, and then to the northern tribes. Thus, a Bor Dinka will be most likely to interact with another Bor Dinka, then any of the other Dinka tribes, then any of the other southern tribes, and then any of the northern tribes. Consequently, agents in a particular tribe tend to interact among themselves and reemphasize their own beliefs.

We use eight beliefs derived from various readings about Sudan and suggested by a SME as being the relevant beliefs; they cover border tensions, tribal

**Table 2.** The Eight Beliefs Used in the Model

Modeled beliefs
Belief that Sudan should remain unified
Belief that Sharia law should be uniformly applied across the country
Belief in respecting Human Rights, as defined by The United Nations (1948)
Belief in respecting women’s rights
Belief in the NCP’s platform
Belief in the SPLM’s platform
Belief that the different intertribal disputes can be resolved peacefully
Belief that the different regional border disputes can be resolved peacefully

Note: NCP = National Congress Party; SPLM = Sudan People’s Liberation Movement.

tensions, religious tensions, and two of Sudan’s political parties (Carley, personal communication, July 26, 2010; International Crisis Group, 2006, 2007, 2010; D. H. Johnson, 2006; see Table 2). Each belief is associated with 10 distinct facts: 5 of these are positive, inclining individuals toward the belief, while 5 are negative, inclining individuals away from it. An unbiased agent’s attitude toward a belief can thus range from  $-5$  to  $5$  as a function of which of these facts they know.

That said, none of the simulated tribe members is unbiased. Each agent possesses a semirandomized bias in favor of or against these beliefs. The bias value is drawn from a normal distribution with mean and standard deviation set based on the region of Sudan from which an agent comes. It is added to the facts that an agent knows to provide a counter to belief derived from knowledge. Bias thus limits the agent’s ability to gain a completely positive or negative attitude toward a belief, even if it knows all of the positive or negative information about it.

Mathematically, we express the bias and belief strength of an agent  $a$  from region  $r$  regarding one particular belief as:

$$a_{bias} \sim N(\mu_r, \sigma_r)$$
$$a_{beliefstrength} = a_{bias} + a_{positive\ facts} - a_{negative\ facts}$$

These numbers are replicated across each of the eight beliefs used. The particular means and standard deviations that we chose were determined based on our research into the Sudan.

As described earlier, we are proposing that intertribal hostility in Sudan can be understood as a function of differing perspectives on a variety of beliefs. To measure the stability of the country at a given point in the simulation, we calculate the average of each of the eight beliefs across the agents within each tribe. We then normalize these beliefs to be between 0 and 1, and calculate the differences between each tribe.

**Table 3.** The Six National Leaders and Their Relationships to the Tribes in the Different Regions of Sudan

National leader	Tie to southern tribes (0.0-1.0)	Tie to northern tribes (0.0-1.0)
Omar Bashir President of Sudan	0.33	1.00
Ali Osman Taha Vice President of Sudan	0.50	0.75
Salva Kiir Mayardit President of South Sudan	0.75	0.66
Hassan al-Turabi	1.0% to 3% of agents, 0.0 to the rest	1.0% to 97% of tribes, 0.0 to the rest
Hard line Islamist		
High-level SPLM leader (generic)	Normal distribution, $\mu = 0.5$ , $SD = 1.0$ (value in $[0.0, 1.0]$ )	Normal distribution, $\mu = -2.5$ , $SD = 0.75$ (value in $[0.0, 1.0]$ )
High-level NCP leader (generic)	Normal distribution, $\mu = -2.5$ , $SD = 0.75$ (value in $[0.0, 1.0]$ )	Normal distribution, $\mu = 1.5$ , $SD = 0.75$ (value in $[0.0, 1.0]$ )

Note: SPLM = Sudan People's Liberation Movement; NCP = National Congress Party.

This yields 91 sets of eight differences. If at least five differences in a set are less than or equal to 0.2, we consider the tribes to have their beliefs aligned. (In other words, two tribes' beliefs are aligned if they can agree on five topics.) The current hostility within Sudan is the proportion of tribal pairs in which the tribes' beliefs are not aligned. The purpose of the Sudan model is to determine if a sequence of interventions could be carried out in Sudan to foster common beliefs among the tribes, decrease their differences, and thus increase the stability of the country as a whole. To carry out these interventions, we introduce a set of intervention agents: leaders who possess more of the facts about these different beliefs (both positive and negative) than do the individual tribe members. Leaders exist at both tribal and national levels, with national leaders possessing greater knowledge than tribal leaders. Tribal leaders are only affiliated with their particular tribes. National leaders have relationships with all tribes, but their influence is limited based on the tribe's region. Tribal leaders are simply assumed to exist, while national leaders were chosen based on readings about relevant figures in the Sudan. (See Table 3 for a list of national leaders and their connections to the regions.)

Leaders are able to carry out two types of interventions:

1. Making a direct appeal to the populace. A given leader will interact with a number of constituents over several time periods. National leaders will interact with the populace for more time periods than will tribal leaders. Instead of focusing on a particular tribe, national leaders will attempt to communicate with all members of the northern or southern region. Tribal leaders interact for a shorter period, but because of their focus on a particular tribe can have

a more pronounced impact on this smaller group. A leader may make a direct appeal to positively or negatively impact any one of the eight beliefs.

2. Meeting in a council with up to three additional leaders. These meetings are intended to approximate the *Tamazuj* forums that occurred in Sudan before the referendum. These forums were a place where different leaders met to discuss concerns and better understand how to address the risks of separation (International Crisis Group, 2010). In simulation, these councils are used to help leaders gain additional information that they did not previously possess. This will then increase their effectiveness when carrying out a direct appeal. A conference can be held on any one of the eight beliefs, but the simulator cannot control the positivity or the negativity of the facts taught at the conference. In this way, we attempt to acknowledge the lack of control that conference organizers may have over the topic discussed. Because national leaders know more than tribal leaders, they will often not get new information from talking to tribal leaders. Tribal leaders, in contrast, will learn a great deal from national leaders. In addition, as the number of people attending a conference increases, the amount of information learned decreases. A larger number of attendees will result in more leaders learning a few facts, as opposed to a few leaders learning additional facts.

Given the set of tribal and national leaders, as well as the number of beliefs that can potentially be manipulated, there are a total of 185,760 possible interventions. Although initially calculable, the simulation is intended to require multiple interventions to complete. Assuming  $N$  interventions, and given that conferences are useless as a final intervention, in a given simulation the total set of combinations of interventions is  $185,760^{N-1} \times 320$ . This number grows exponentially. Consequently, carrying out a complete set of simulations for any extended duration is impossible. We consider 20 intervention periods to be a reasonable maximum number of interventions in which to make the simulation converge, but given the aforementioned number of combinations available have not exhaustively demonstrated this success. (Indeed, if we had definitively done so, actually using human players would be superfluous to our purposes.)

## Testing

While an exhaustive test of the model is infeasible, we can perform limited tests of it to try and determine the maximum and minimum hostility values that can be achieved at any one intervention period. To do so, we take a greedy approach to choosing interventions, opting to commit to whatever intervention scores the average lowest hostility given its use at a particular time period. For each intervention period—in sequence—we run at least 30 replications of the 320 possible direct interventions and determine the 1 that, on average, results in the lowest net hostility score. We run the simulation for a total of 20 intervention periods, and so make our choice based on the intervention that will create, overall, the most minimum hostility scores at the present intervention period and all subsequent intervention periods. Our current results (tests are ongoing) are shown in Table 4.

**Table 4.** Hostility Change Over Time Given Optimal Choices Under Perfect and Imperfect Tribal Knowledge

Intervention	Imperfect knowledge			Perfect knowledge		
	Minimum hostility	No. of minima	Maximum hostility	Minimum hostility	No. of minima	Maximum hostility
1	0.4725275	1	0.5274725	0.4615385	2	0.5274725
2	0.4615385	1	0.5274725	0.4725275	6	0.5274725
3	0.4725275	2	0.5274725	0.4725275	1	0.5274725
4	0.4725275	1	0.5384615	0.4725275	2	0.5164835
5	0.4615385	1	0.5274725	0.4835165	290	0.5274725
6	0.4725275	4	0.5384615			
7	0.4725275	1	0.5274725			
8	0.4725275	3	0.5274725			
9	0.4835165	283	0.5274725			
10	0.4725275	1	0.5274725			

Note: The minimum and maximum hostilities registered for the current intervention, as well as the number of interventions that can produce this minimum value. The results are split based on whether the leaders have perfect knowledge of all facts or limited knowledge of certain facts. That is, the first row shows the minimum and maximum possible hostility values that can be attained after taking just one intervention; these values are calculated by projecting ahead across 20 intervention periods and calculated across all of them. Note that in the event of multiple minima, we only choose one of them at random, incorporate it into the model, and then continue calculation. Thus, the forks at Interventions 3, 6, and 9 in the left-hand table represent serious limitations in our exploration of values.

A key limitation of this testing approach is that it excludes the interventions modeling the Tamazuj forums. These have no obvious immediate payoff, so our testing algorithm cannot adequately account for them. As a rough approximation, we have tested an alternate version of our simulation where all individuals have perfect knowledge—as if the forums had been maximally effective. We thus capture two potential extremes of results, and can at least gain a sense of maximally and minimally effective strategies.

The results indicate the difficulty of both reducing the overall hostility and of making an optimal choice. The table shows that the total range of hostility values is fairly small: the lowest minimum, 0.4615385, occurs when 42 tribal relationships are deemed hostile; the greatest maximum, 0.5384615, occurs when 49 relationships are deemed hostile. This apparent inelasticity is an artifact of the number of beliefs linking individuals; the actual causes of hostility may be quite diverse in any particular one. (In one replication, two tribes are considered at odds because they differ on women’s issues. In another, the same tribes are in conflict over Sharia law.) That said, the minimum and maximum values that we see at each intervention point remain almost completely constant. Because the goal of these simulation runs has been to consistently choose the action that minimizes hostility, this suggests that by choosing the best action at any one time period, we only maintain Sudan in a holding pattern, postponing the increase in hostilities. That said, because we are striving for a minimum value, it is

quite possible that the maximum hostility values we see are markedly less than the actual maximums that can be achieved. Second, note that at the ninth intervention in our worst case scenario, we see an immense mushrooming in the number of possible optimal choices. We might interpret this as a solution—suddenly, most interventions are optimal—but given that none of these options are markedly less than previous hostility levels, we might say that every option fails. This mushrooming also emphasizes the difficulty of testing our model. In our current tests, we do not look at each best case, but instead randomly iterate and then examine only one of the results. Random choices made at the third and sixth iterations have led us to the situation at the ninth. This is not thorough, and potentially omits any number of better options as each of these initial choices yields an increasing set of forking results.

Lastly, note that there are no noticeable performance differences between the optimal and suboptimal knowledge situations. This suggests that the current relative simplicity in the number of facts minimizes the effect of the Tamazuj forums. By increasing the number of facts in the actual game, it should be possible to more accurately represent the forums' benefits.

We draw two conclusions from the results of these tests. The first is that, given the difficulty of mastering our current hostility metric, we may want to develop an alternate hostility metric that will make the game simpler for the player. Once they have beaten this easier version of the game, they may be interested in trying the more difficult version. The second implication is that we need additional tests that can deal with such mushrooms in the possibility space. The best way to do this will be by choosing the best option for each simulation on a case-by-case basis, as opposed to averaging across multiple replications to find an optimal option. This method will not provide us with an idea of the best intervention to take a particular time period, but will give us a much more accurate reading of the range of possible values available.

## **The Game**

The SUDAN GAME is a front end to the Sudan model. Its purpose is to hook into the model to make it amenable to real-time human manipulation. In the game, the player takes on the role of a UN official in Khartoum, tasked with easing the tension present in relationships between the Sudanese tribes. This role is highly fictionalized—The player's actions do not resemble the actual actions available to any one real UN official. They can be understood as an aggregate of different actions on the part of the UN and other outside groups that result in a particular sequence of real-world steps being chosen.

As the official, the player talks with the different Sudanese leaders to learn their perspectives on how the different tribes should be influenced, and then asks one of the leaders to make a particular intervention on the population. (Either a speech intervention or interleader conference, as described before.) The chosen intervention is sent to CONSTRUCT, which runs and feeds the results of the simulation back to the game. We consider 20 interventions to be a reasonable maximum number of turns for the player, though this may be adjusted to optimize playability and enjoyment.

## *The World*

Our game is implemented as part of COSMOPOLIS, an MMO that is under development and will contain a variety of subgames (GamePipe Laboratory, 2011). It uses COSMOPOLIS's engine to create the SUDAN GAME's world. This choice of platform helps dictate the audience that will be playing the game. COSMOPOLIS will be released for free on the Internet, but requires a relatively high-end computer to process its graphics. It is themed to approximate reality; avatars are human and clothing and other artifacts match the present day. In addition to the SUDAN GAME, COSMOPOLIS will also host other games developed at the design school. This combination of elements leads us to expect that our primary player base will be an audience that is interested in games and regards themselves as serious gamers. Given that the game is open to all, however, it is certainly possible that we will see other demographics as well.

The environment consists of 21 avatars, gathered in three areas in a walled meeting enclave. One set of avatars are the Sudanese leaders who function at the national level, one set are the Sudanese leaders who operate at the local level, and the third set contains just one avatar: an overarching UN representative who can provide a larger set of data.

Our choice of an avatar-based design for the SUDAN GAME was informed by the conventions of the COSMOPOLIS outer game. More abstract methods would require significant subverting of COSMOPOLIS's engine and general look and feel. Using avatars works both for and against us. Maintaining a consistent style helps to make migrating from the outer to the inner game a much more fluid experience. However, the avatar-based system slows down the player's ability to interact with the underlying model, getting in the way of the most salient parts of the game (Figure 1).

## *Interactions to Understand the World*

As noted earlier, the game's success is contingent on players having enough salient information to make a decision. Players are given this information in several ways. At the start of the game, the player is given a brief description of the situation in Sudan. The UN representative engages them in a dialogue that provides additional information. Last, each leader provides some descriptive text about who the leader is and their relationship with the different tribes or regions of Sudan. Dialogues are presented as short narrative text pop-ups, as in other MMOs such as WORLD OF WARCRAFT. Players are occasionally given dialogue choices, but these only navigate through static text and do not change in response to particular actions (Figure 2).

## *Interactions to Decide on Interventions*

While the leaders' description are intended to give people an understanding of some of the salient aspects of the Sudan, we want their decisions to be driven by analytics about the beliefs held by and tensions between the different tribes.



**Figure 1.** The player in the game world

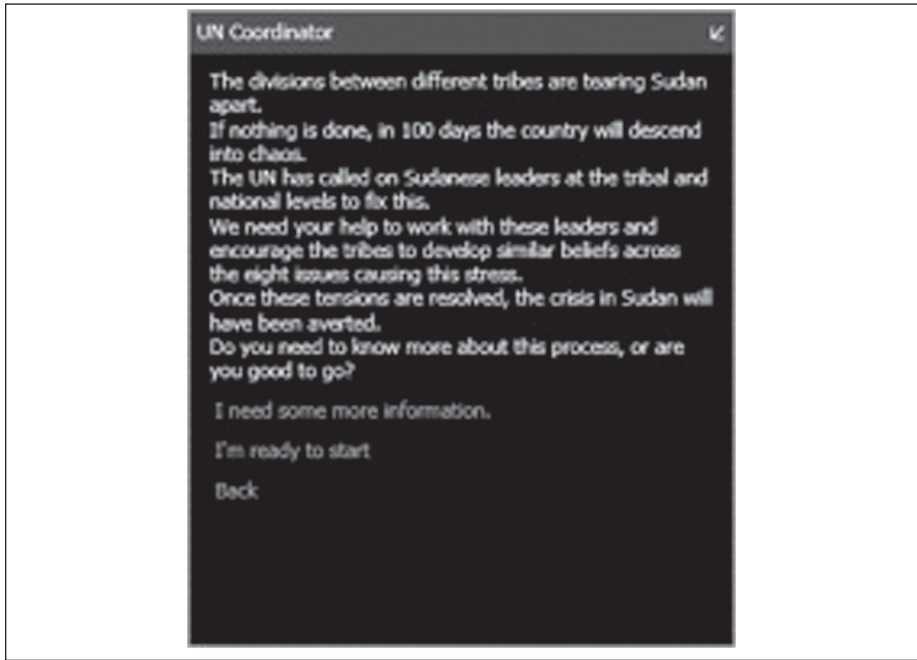
Note: Around the campfire in front of her stand the different tribal leaders. Around the campfire to the left stand the different national leaders. Offscreen, just outside of the passage through the wall on the right, stands the UN coordinator.

When talking to the different tribal and national leaders, leaders provide the player information about the strength and positive or negative direction of the beliefs held by each tribal group. Tribal leaders will report on the beliefs of their own tribe, while national leaders will provide information about attitudes held in the North and South. By comparing these values, players can determine the best difference in belief for them to address. They can also determine the amount of knowledge that a leader has about a particular belief, which helps them to understand whether that leader should conference with other leaders before they carry out a speech intervention. As in the non-playable model, interventions are carried out sequentially. Players may only choose one intervention to be carried out at a time.

Unlike the informational dialogues, these displays incorporate different interactive elements. For conferences, tribes are chosen from lists of checkboxes, while interventions are chosen via particular submenus. Intertribal hostility is plotted as a graph over time, and beliefs are displayed as a floating indicator between two extremes (see Figures 3 and 4).

### *Winning and Losing*

The player is permitted 20 interventions to try and get the intertribal hostility value below 0.2. As soon as they succeed in dropping hostility below this critical value, we consider them victorious. The challenge of the game will come from optimizing performance against these semirandom circumstances. Depending on the game's success, it could be followed with variants based on more pessimistic



**Figure 2.** The introductory message from the UN coordinator  
Note: The player sees this when they first speak to the coordinator at the start of the game.

and more optimistic scenarios about the country (increasing or decreasing the difficulty correspondingly). We fully acknowledge that the intervention count and hostility level are arbitrary limits and may need to be adjusted—especially in light of the range of hostilities suggested by our initial tests. The real goal here is to minimize tension as quickly as possible. The precise values and number of interventions permitted are intended to create additional challenges for the players and to confine the experience—a necessity for an online game that is only one part of a larger online experience.

*Extra-Game Collaboration*

The SUDAN GAME does not have any collaborative features at present. Every player plays by themselves, with results after games finish. However, players will interact within the larger framework of COSMOPOLIS itself; their successes and failures in the game will be tied to their account, and the SUDAN GAMES’s aesthetic ties it inextricably to the outer game. We will be capturing discussions in COSMOPOLIS in which the SUDAN GAME is mentioned in order to better understand players’ attitudes toward the game. We will also set up a forum for dis-



**Figure 3.** Sample image of the Bari Chief’s intervention panel

Note: SPLM = Sudan People’s Liberation Movement. For each belief, the Bari leader gives an approximate measure of the positive or negative information they possess about a particular belief and can thus use to influence their tribe. The bar displays the leader’s tribe’s attitude toward the particular belief, and includes buttons for choosing a particular intervention. Because national leaders intervene on the northern and southern regions of the country (as opposed to on one tribe), their interface differs to reflect their national scope by displaying two bars—one for attitudes in the North of the country and one for attitudes in the South.

cussion of the game on the main website for COSMOPOLIS. In both situations, we will be inspecting the conversations to try and understand players’ attitudes toward the game. We will also be looking for discussions of the strategies taken by players and their perceptions of the game. The SUDAN GAME is designed to present the information that players need to make decisions about interventions within its framework. By looking at how they decide on strategies, we will be able to better develop the information to be displayed in future iterations of the game.

### Expected Results

We expect our work to yield two primary results. The first of these is a set of combinations of different intertribal forums and interventions by Sudanese leaders that significantly decrease the belief differences between Sudanese tribes to the point



**Figure 4.** The interface for setting up conferences between different leaders, accessed by speaking to the UN coordinator  
Note: NCP = National Congress Party; SPLM = Sudan People's Liberation Movement. The player chooses the belief that will be the topic of the conference and the leaders who will participate.

where hostility between tribes becomes unlikely. A percentage of the game's players will successfully develop complete solutions that equal or improve on the range of hostility values that we have found for the country. We will take these solutions and test them with a large number of replications in simulation. A smaller percentage of these results will be shown to be resilient over numerous replications, and we will consider these results to be good suggestions for consideration in formulating a policy approach toward issues in Sudan. For example, a player might win the game by holding periodic Tamazuj forums between tribal leaders and Bashir, on the topics of women's rights, the ability of the tribes to peacefully resolve their conflicts, and the belief that Sudan should be separated. They would then have the different tribal leaders meet with their tribes and encourage these particular beliefs. Assuming that this user's method shows consistently declining hostility in simulation, we would argue that it would have been a good fit for policy implementation—that had the UN, the United States, or other diplomatic agencies worked to get Tamazuj forums organized on these topics and then dispatched participating leaders to address these issues

in their tribes, it would have been an effective strategy for limiting postreferendum violence. (An updated version of the model, taking into account the current situation of Sudan and South Sudan, would be necessary in order to test out new policies.)

We have made simplifications to the politics of Sudan described in the model, and it is possible that these simplifications will result in our results being criticized for lack of realism. This is irrelevant from the standpoint of our prototyping a new system for developing policy recommendations via gameplay. The validity of our general model of belief is significant because of our specific integration of CONSTRUCT—a belief modeling system—with COSMOPOLIS, but any model could be similarly integrated into a game. That said, the beliefs and particular network configurations for our model have been validated by SME opinion, our data are derived from real sources, and the underlying CONSTRUCT belief model has been validated in other experiments.

The second result we desire from this set of experiments is data describing how individuals interact within COSMOPOLIS and its forum. Such interactions will help us understand how individuals are experiencing the game—what works and what does not—and why they make particular intervention choices. For example, the player behind the solution, discussed above, may discuss how she consistently sees women's rights as a critical issue; if other players agree, we might consider this indicative of both the significance of women's rights in the model and also the appeal of that issue to our players. It is important to understand how the information you are giving the player is being used to evaluate the solutions that they put forward. The player may be making choices based solely on the numbers they are seeing, or they may be employing a deeper, long-term strategy. It is not in any way critical that the players have a deeper understanding of Sudan, but we must understand how our model matches the one they are constructing in their minds as they play.

## **Discussion**

We have defined our results for Sudan in terms of how well our methods find optimal results and the nature of the collaboration that we see between the players. In this section, we consider the implications of the possible combinations of results that we might see, as well as the ways in which our methods might be generalized.

The most basic results that concern us are whether players are winning the game. Assuming that our model is correct, we consider all winning solutions to be guides for policy development. Winning solutions that are robust enough to withstand multiple rounds of simulation would be deemed actual workable possibilities for policy guidance, and should be compared for overarching similarities (e.g., Do these solutions tend to feature conferences in the first few rounds? Do they not use conferences at all?). The end goal for this project is effectiveness.

Besides winning players, we also hope to see evidence of positive interactions and collaboration in both the game world and in the game's forum. Positive collaboration, by our metrics, would be indicated by player discussion of the game, how to win it, and the general environment. In an ideal situation, this discussion would provide a

perfect map of the reasoning used by different players to win. Reasoning based on the game as presented can be used to understand how players are interpreting the different signals and messages in tribes to help build future games. Reasoning about the underlying mathematics of the simulation would be useful in helping to build and improve on heuristic processes used by players.

Getting perfect data is of course by no means guaranteed. If players simply voice approval for the game and interest in it, we will regard this as positive feedback. It will be an indicator that the game mechanic is compelling, and will suggest that we can conduct future experiments using a similar form of user interaction in an avatar-based world for experiments.

Our worst case for interaction information will be either complete lack of feedback or negative responses that suggest that players simply fail to engage with the game. As we are relying on our ability to draw players in based on the quality of the gameplay and the game's world, if these things fail to compel then we will need to dramatically rethink our approach to the game. This would mean discarding or modifying our game design sufficiently to address all expressed player issues.

Player response to the game is significant because it will suggest the feasibility of designing additional games that incorporate CONSTRUCT models into their design. The CONSTRUCT interaction model posits a world in which agents exchange specific facts to create different beliefs, and the SUDAN GAME is a fairly direct attempt at turning this particular model of interaction into a game. Both the principles underlying the model and the methods used to extract the data are generalizable to other contexts. We could conceivably build a similar model of one of the Arab Spring countries on the verge of revolt. In such a variant, the player might be tasked with spreading facts to various bloggers and influential protesters to try and create a belief that victory over the regime is feasible. Successful player solutions would result in revolution matching that which occurred in the real world.

Such a different game would require some customization to provide relevant contextual information to the player, but this data could be assembled using processes similar to the analysis of newspapers and SME validation used for the SUDAN GAME. Provided that the SUDAN GAME's central mechanic is of interest to players—or once it has been reworked to be of interest—we will possess a method for creating a particular style of game for studying the propagation of beliefs via particular facts.

## *Future Work*

The most immediate future work ahead of us is releasing the game and running further tests of our underlying model. More sophisticated tests will help us to better predict the outcomes that we will see from the game and further tune our results, while releasing the game will mean that we actually garner real data.

In the long term, there are several avenues for future work suggested by this project. The first, as mentioned in the “Discussion” section, is creating additional games

based on this principle of belief diffusion. Future work could concentrate on embedding other scenarios characterized by belief instability and sequential interventions on these beliefs. These scenarios could include ongoing conflict (such as the current state of Sudanese and South Sudanese relationships) as well as historical examples (such as the breakup of the USSR or the Tibetan-Chinese conflict). While examining current scenarios can be used to help develop policy, older scenarios can be used to examine counterfactuals that can be applied to the present. Could the Soviet Union have prevented from students' believing in the possibility of a Prague Spring, and how can those interventions be applied in the context of the Arab Spring?

While we hypothesize about the generalizability of our methods, it is only through the creation of other games that we can actually demonstrate it. We specifically want to develop methods for automatically instantiating such games by rapidly refining the backend networks such as those that underlie the Sudan model from source texts, converting them to CONSTRUCT models, and then pairing them with appropriate visual assets and contextual information for players.

Second, we should also test the impact of using a simpler interface when using the Sudan model. While COSMOPOLIS features a rich, three-dimensional environment, the decisions our players are making are based almost wholly on two-dimensional graphs of relative beliefs and text. Alternate versions of the game that feature either richer graphics (three-dimensional graphs and comparisons) or sparser displays (cutting out the MMO world entirely) may be more understandable for players. By understanding how people use the interface, we will be able to better control their interactions with the game and consequently cultivate better results for our model.

### Authors' Note

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies, either expressed or implied, of the Army Research Institute, the Office of Naval Research, or the U.S. Government.

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