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MODULAR APPROACH TO DESIGNING COMPUTER CULTURAL SYSTEMS: CULTURE AS A THERMODYNAMIC MACHINE

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ABSTRACT

Culture is a complex non-linear system. In order to design computer simulations of cultural systems, it is necessary to break the system down into sub-systems. Human culture is modular. It consists of sets of people that belong to economic units. Access to, and control over matter, energy and information is postulated as the key to development of cultural simulations. Because resources in the real world are patchy, access to and control over resources is expressed in two related arenas: economics (direct control) and politics (non-direct control). The best way to create models for cultural ecology/economics lies in an energy-information-economic paradigm based on general systems theory and an understanding of the "thermodynamics" of ecology, or culture as a thermodynamic machine.

KEY WORDS

cultural ecology, thermodynamics, systems theory

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INTRODUCTION

The separation of environment from culture is artificial. It is my view that the environment consists of three interdependent sub-sets:

1) The physical environment consisting of geomorphic surfaces and their hydrologic structure within a climatic regime (soils, topography, light, humidity, temperature, seasonality, rivers, streams, lakes, ponds, oceans, etc.). It includes a mosaic of minerals valued by human groups. The physical environment tends to be the slowest to change, fluctuate and also tends to be the most predictable for modeling. Key variables in this sub-system include water, minerals such as tool stone, relative climate impacts to plant and animal distributions and seasonality, presence or absence of water in hydrological systems and ambient temperature relating to factors such as shelter. At a gross level, variables tend to be more simplistic and mechanical as well as linear. This environment tends to be dominated by “matter” as a resource, but must be “mapped” and “categorized” as information,
2) The biotic environment consisting of plants and animals and their ecological relationships to the physical and cultural environments (distribution, biomass, diversity population, etc.). This sub-system is more likely to change, fluctuate, and is more difficult to predict and model. Key variables include plants for food, fiber, and wood for tools and cooking; animals for food, hide, fur, feathers, bone and sinew. Variables tend to be more complex and non-linear. This environment tends to be dominated by “energy” as a resource, but is based on matter and must be mapped and categorized by informational systems,
3) The cultural environment consisting of cooperating and non-cooperating other human beings and their relationship to the physical and ecological environments. This sub-system is the most likely to change, fluctuate and is the least predictable for modeling. The key variable is the cultural idiom for access to, and control over resources, and information about the location, distribution and relative abundance, activity and predictability of resources in all three environments. Culture is the idiom that expresses, in symbolic forms, how human groups map access to, and control over, valued resources. This environment tends to be dominated by “information” Culture is an informational milieu.

A thermodynamic characteristic (in fact, requirement) of cultures is their ability to map out matter, energy and information about resources, their relative distribution, relative abundance, relative activity, and relative predictability. There is an isomorphic correlation between the form (demands) of general living systems and economics as a model. This is why economic models work so well. Since economics and ecology share common roots, ecological models also work well in anthropology.

“The environment, however else it may be characterized, can be seen at bottom as a set or ensemble of more or less distinguishable elements, states, or events, whether the discriminations are made in terms of spatial or temporal relations, or properties. Such distinguishable differences in an ensemble may be most generally referred to as ‘variety’. The relatively stable ‘causal’, spatial and/or temporal relations between these distinguishable elements or events may be generally referred to as ‘constraint’.... When the internal organization of an adaptive system acquires features that permit it to discriminate, act upon, and respond to aspects of the environmental variety and its constraints, we might generally say that the system has ‘mapped’ parts of the environmental variety and constraints into its organization as structure and/or ‘information’ ” [1; p.491].

Humans are born into family groups. Such groups must have access to, and control over, resources necessary and sufficient for self-maintenance and growth. Growth is a requirement simply because all life must push against its inherent limits and random chance disorder. If life did not do this, it would cease to exist sooner or later. Human groups, usually based on kinship in small-scale societies, form the basic economic firms of production, distribution, storage and consumption. These are the modular units that are basic to this paper. They are essentially identical in small-scale societies, and grow in variety and complexity with population growth and in the face of increasing demands and supports. They can be modified through their respective economic technologies of production, distribution, storage and consumption. They can be modified through their technologies of political control as well. In addition, within each of the three sub-environments are variables that can be manipulated to modify carrying capacity. As might be expected, the more active and symbolic variables are subject to the greatest chance for manipulation and change ... in fact, they are designed for manipulation. The symbolic idiom is set up to be loose, and allow for changing circumstance as the players change as they are born, age and die.

Figure 1 illustrates the model of the interrelationship between the demands of systems frameworks and economic terms. The general systems terms are on the left and their isomorphic economic parallels are on the right.

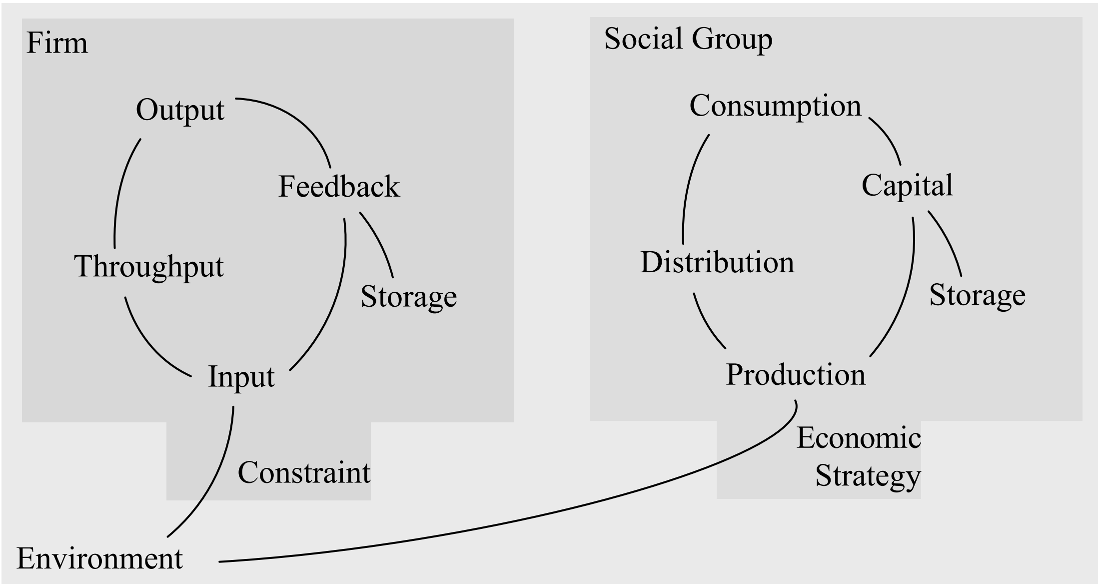

Figure 1. Model of the interrelationship between the demands of systems frameworks and economic terms.

All systems consist of sub-systems that are isolated from other sub-systems as "entities" by a set of constraints (i.e. they have limited material, energy and information flows at some boundary) as well as a primary means of material, energy and information input (constraint). The sub-system is an "entity" of "firm", an internally related group of variables more or less isolated (never completely) from external factors. The correlation between systems variables and economic variables is clear from Figure 1: input equals production, throughput equals distribution, feedback equals capital or investment, output equals consumption, while storage is "feedback" kept on hand more or less in stasis until needed. The basic constraint is a set of variables that control input which is the economic and political strategy (adaptive framework) of the social group or "entity". Just as feedback (material, energy or information) is used to modify input, throughput or output ... capital/investment (material, energy or information) is used to modify production, distribution and consumption.

In small scale societies where storage capability is limited, energy is stored less often as food material and more often as information through “reciprocity” (i.e. invest or convert short shelf-life goods to immediate use by cooperating other human beings, and create a “debt” that can be called in the future stored as information ... which has a longer shelf-life).

Social groups or entities, use exploitive technology and strategies to maintain access to and control over valued environmental resources: physical, biotic and cultural. They gather resources directly or store information about resources and their relative abundance, predictability and activity. They also create a complex cultural idiom to store or invest matter, energy or information for manipulation of cooperating and non-cooperating other human beings. If kinship, marriage, economics, politics, law, warfare and religion are examined within this paradigm, they show up as complex “maps” of control systems. They are a form of ecological contracts between parties expressed in complex symbolism. Since circumstances change, since living systems are dynamic, and since individuals are born, grow through stages, and die, the contractual idiom is kept in symbols that can be interpreted in many ways (deliberate vagueness). In small scale societies, their re-interpretation is the subject of almost constant public consensus debate. In large scale societies, re-interpretation keeps lawyers employed.

Breaking down societies into modular “firms” is my way of modeling the cultural ecology of human groups. It creates a simplified but valuable tool to understand how a particular society functions.

Language is a technology, no different than technologies of production, distribution and consumption. Language and symbols are a symbolic milieu constructed with the intent of “looseness” (randomness) or noise. The idiom is designed so that it can be interpreted and reinterpreted by constant “consensus” activities (that oscillate and converge on some broad and loose meeting for many players and agendas). Language is designed to allow communication of symbols but at the same time to be non-linear in interpretation. It is not designed to be precise, but to be vague as to allow for changing circumstances. It must be rich and complex and non-linear as it reflects the complex inter-relationship between the physical, biotic and cultural environmental sub-systems. Language is simply a technology, a way on manipulating not only the hard physical resources of the three sub-systems, but as a way of manipulating cooperating and non-cooperating other human beings in relation to those resources (including the humans as resources and their “information” about the resources) and access to, and control over, those resources.

“Cybernetics is the science of communication and control. As such, it does not examine transformations of energy. It examines patterns of signals by means of which information is transmitted within a system and from one system to another. Transmission of information is essential in control, and the capacity of a system to exercise control depends on how much information it can process and store. In fact, the concept ‘quantity of information’ is central in cybernetics. In this context, ‘quantity of information: is unrelated to the meaning of the information, its significance, or its truth. Quantity of information is related simply to the number of decisions’ which must be made in order to reduce its range of possible answers to the question one asks; to put it in another way, to reduce uncertainty” [1; p.xix].

The term “production” is a linguistic tag for “input”; “distribution” is a tag for “throughput”; and “consumption” is a tag for “output”. There has been recent work in “fuzzy” theory concerning the meaning of words as mathematical sets. Fuzzy logic expresses the world in both terms of possibility and probability. It uses logic truth-values associated with words, not numbers. Fuzzy truth tables are imprecise and fuzzy rules are approximations. Bart Kosko was able to prove through hypercube matrix analysis that probability, including Bayesian axioms, is a subset of fuzzy theory. In showing that axioms of probability can be derived as a theorem that can be proved under fuzzy logic, he relegated probability to a sub-set of fuzzy logic [2-4]. Fuzzy logic may be the key to breaking the thermodynamic code of language.

As noted. Growth is a requirement of life. Humans are living creatures. As human populations expand, the demands on resources increase and the pool of players increases. As such, it has what appears to be evolutionary change, if one views increasingly populous systems as falling into some kind of evolutionary ladder. They do become more complex, simply because of the law of large numbers: any complex system branches into sub-systems. This is a practical reality ... sub-systems specialize to allow increased complexity. A complex multi-cellular living being cannot live without sub-systems such as digestion, information response, processing, circulation, etc. This is exactly what happens in cultural systems as well. With increasing population loads, the culture breaks up into specialized sub-systems (or firms). In evolutionary terms the amount and variety of such specialized sub-firms can be used as a measure. With such proliferation, there is the growth of specialized symbols that define the operation or process of the sub-entity. As complexity grows, there is asymmetry and every asymmetrical, connected, and transitive relation establishes a serial order. The cause produces the effect and the effect records the cause. Anything is possible, but fewer things are probable.

All information is a form of "capital" as well as a "resource". In highly complex systems, the young must be taught the necessary and sufficient information for basic survival. Some will recognize that mastery of this "information" is the key to relative wealth. This allows some level of asymmetrical use of information in all systems. The smaller the system the more homogeneous it is in structure and there are fewer opportunities for relative wealth. But at all levels there is some leeway. There are always some who score a bit more of the resource pie, who are a bit more able in symbolic manipulation, who "play the game" with a bit more élan or skill. Small-scale societies are tied more directly to their biotic and physical environments than complex ones. The agent(s) of production, distribution and consumption tend to be limited to a person, family or other kin groups. Social groups tend to be homogenous, each pretty much a mirror image of all others. The more complex and larger the society, the more diverse social entities can become and the more divergent in structure and composition they become. They can also become specialized sub-entities, with little to do with primary food, material or energy production. This modular nature of cultural systems is the key to computer simulation models.

The proliferation of specialization, in productive firms in more complex societies, means the proliferation of specialized jargon. As any technology is changed through some artifact invention or some way of "defining" access to, or control over any physical, biotic or cultural resource ... terminology expands. This applies not only to the internal economic realm, but also to the patchy political realm of control. Just as an economic firm may specialize in distribution of a resource, or the production of a resource, in complex systems, those who pull the political strings can specialize into the political arena of social control over patchy resources. As information proliferates and specializes, groups can capitalize on control over information as a resource. All resources contain some level of information about their location, their motility, their relative abundance, etc. In addition, technologies related to their exploitation (production, distribution, consumption, storage) are subject to access and control issues (politics).

In low-level population density ecological systems, free access to essentially all facets of production, distribution, consumption and storage is validated in the shared linguistic system. As populations grow, and specialization occurs in productive and/or political firms ... specialized terminology grows. As such, this form of information becomes a kind of capital as well.

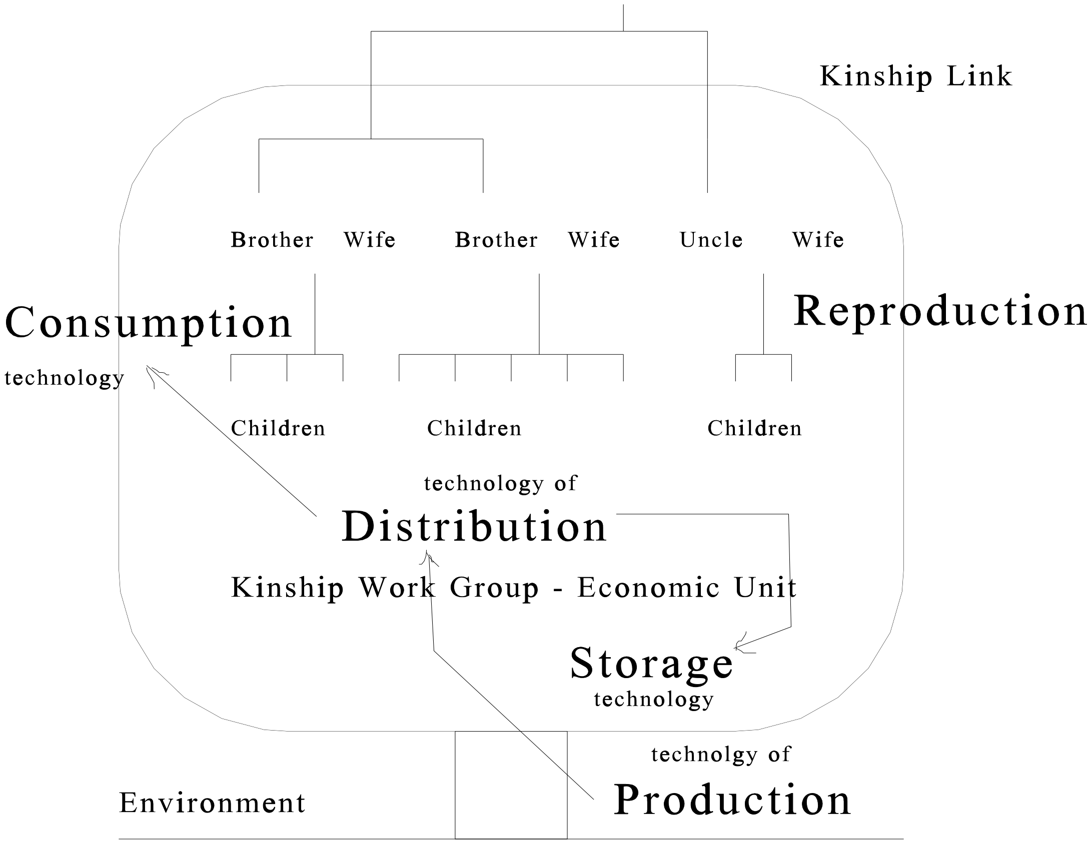

Figure 2. Example of an uncomplicated family-based cultural system unit.

There arises the possibility, indeed the probability, of firms devoted to controlling information alone as a product. Not only do complex systems become asymmetric in relation to production, but complex societies thus become asymmetric in relation to the society's own language!

ONLY VARIETY CAN REGULATE VARIETY!

Figure 2 is an example of an uncomplicated family-based cultural system unit. The example is based on a patrilineage model. Groups of related brothers, their wives, and children, perhaps uncles and their families, become the basic economic unit of production, distribution, storage, and consumption. They exploit the environmental resources as a cooperative unit. They may own rights to specific resource plots together. They may include other relatives who prefer their company and benefits. Such a unit may be the basis for a complex winter pit-house, where each family has a hearth and associated bed-shelf around a common hearth area. The eldest brother may be the group leader for political activities in relationship to patchy resources and non-cooperating other human beings. Such a unit would repeat over and over in small-scale societies, only the numbers of participants and their skills making the little difference between any two units of economic or political power. Cultures can be broken down into such production units. The larger, and more complex the system, the greater variety in unit function. Units in very complex systems can be so specialized that they take over a single aspect such as relatively pure production, or distribution. Units may specialize in type of production, or gain specific technical skills to produce artifacts or information for distribution in exchange for matter, energy or information. The repeatability of such units allows modeling of cultural systems.

Cultures change because of changes in the physical, biotic or cultural environments and more importantly because populations grow. Any variable in the complex system can changed and thus change carrying capacity. Technologies of production, distribution, storage, and consumption will change as each unit of production jockeys to meet its internal demands. Production units can attempt to increase access to, and control over, valued resources in all three environments. The adaptive/economic strategy can be modified, and this modification will modify carrying capacity. The resultant changes are often seen in "evolutionary" terms in anthropology. There is nothing linear about which variable or combination of variables might change. Change in any variable tends to create the possibility of more change in that variable (within self referencing limits) because of feedback loops. There can be gradual changes in existing variables or a change in degree so great as to be a change in "kind" of the variable. For example, gathering can intensify within a natural biotic system. Groups can shift to fire to modify a biotic system (low level plant/animal management) to increase valued biota, but still gather wild plant products as the primary source of production. Groups can then begin to manipulate the plants and/or animals such that they are no longer natural species, and are now dependent on humans. Groups are no longer gatherers, they are plant/animal managers (i.e. agriculturalists/herders).

Politics is generic managerial control over, and access to, valued resources of the society of cooperating human beings as a whole as opposed to non-cooperating other human beings. No social group operates in a vacuum. All resources are irregular in distribution and density. All groups impinge on the resource territories of other groups. This interleaving of resources and resource needs creates a demand for access and control systems expressed either as economics (mostly internal) or politics (mostly external). They blur together at many levels within the idiom (symbolism) of the culture. Politics evens out patchy resource issues.

All human beings operate within a social framework defined in the cultural idiom. All human beings exploit matter, energy and information in a social matrix of cooperating and non-cooperating other human beings. Cooperative economic and political action reduces variation in access and control over valued resources and changing conditions. Cooperative sharing of information within a cultural framework increases the range of information about the three environments, increases alternatives for dealing with fluctuations in the distribution of valued resources. It also increases alternatives in the face of random chance disorder as well as increases access and control in the face of non-cooperating other human beings. There is always some point where human beings are in a position of competition, active or passive, for valued resources. This can arise from internal or external expansion in numbers. Cooperative economic and political action reinforces mutual rights and smooth out differential distribution of resources within the environments. For example, in many slash and burn agriculturalists, active and fallow fields co-mingle. Group control over fields allows many sub-groups based on expanded family kinship groups access to fallow fields as resources without active competition. Group cooperation creates a mosaic of zones and relationships that express this active and passive cooperation and passive and active competition. Human beings manipulate each other through symbols (the cultural idiom) to control access to such resources.

The network of interrelated and intercommunicating human beings creates social groupings. Shared needs and values decrease to competitive needs and values through a continuum. The fundamental social "entity or firm" is found repeating throughout the social system within variations. Each person is born into an existing cultural milieu. Each person learns the network of demands and supports from nearby other human beings. Not all learn the same information, and the information is always "loose" to allow manipulation. This shared learned information is the cultural idiom. Some members are better at the process than others. The symbolic idiom sometimes seems superficially remote from human-land, human-biota, and human-human relations. The very active human side of the equation often masks the more passive biotic and land relationships. Symbols can represent an action, or class of actions, with its/their associated demands and supports.

Other human beings, whether cooperative, or non-cooperative, are the patent manipulators and are the most active variables in changing relationships to resources. People manipulate people to reach a real energy, matter or informational end. Manipulation of people through complex symbols is the means to an end. There is never one solution, but a complex and very rich cultural idiom that defines access to, and control over, valued resources in all three environments.

Culture is thus a dependent phenomenon of this manipulation and is isomorphic to the demands of living systems and the thermodynamic process. It operates as a filter between human beings and human groups. It contains latent values (associated with matter, energy and information) related to access and control of resources and all resources are patchy to some extent. There are seasonal and long-term cyclical and linear patterns of changes in the physical environment. The biotic sub-system fluctuates more strongly seasonally and also exhibits climax vegetation and long-term cyclical and linear changes as well. The cultural sub-system is the most active in change and fluctuations (fission-fusion-flux).

Because all resources are patchy to some extent, political idioms are created. There are seasonal and long-term cyclical and linear patterns of changes in the physical environment. The biotic sub-system fluctuates more strongly seasonally and also exhibit climax trends and long term cyclical and linear changes as well. The cultural sub-system is the most active in change and fluctuations (fission-fusion-flux). All resources can be placed into a scale that defines them as relatively predictable, relatively abundant and relatively active or sessile. Physical resources are the most predictable and the most sessile, and abundance is patchy but fairly universal regionally. For those resources that are valued and very patchy, trade networks arise for their distribution. Biotic resources of importance to the primary exploitation strategies tend to be those that are the most abundant, predictable and sessile within the demands for food, fiber, wood, skins, sinew, bone and horn (there are others like feathers, fur, claws, etc) as well as such things as "taste", "texture", "odor", as factors in value and use.

"A system cannot be regarded as stable unless there is a guarantee that the resources on which it depends will always be available. The only way it can ensure this is to live off the interest and not the capitol of available resources" [8; p.73].

A system containing non-biological (cultural) technologies can change the technology as a form of interest on resources, increasing output (production), increasing efficiency in any sub-part, etc.

Although the model is matter/energy/information dependent, there is no one to one correlation between social entities and their complex of environments. All social entities have an exploitive strategy that is a mix of all three environments. Every strategy is a compromise reflecting all three as subsystems of an overall environmental exploitation process.

Another key aspect to this cultural overview is culture's symbolic milieu (religion). As cultural animals, humans create rich symbolic idioms that attempt to categorize and understand everything.

Human culture is a symbolic milieu for operation of a thermodynamic machine filled with non-linear mutual causal feedback loops. It is designed to be loose, to be subject to differential consensus or interpretation. But it is also inherently systemic and thermodynamic in its internal firm-like structures are used to control interaction with the physical, biotic and cultural sub-systems. It is modular. Religion is the "symbolizing" of the symbols and related processes. It validates access to, and control over, valued resources in the physical, biotic and cultural environments.

Anthropology has shown, for example, that burial of the dead is often used to validate ownership rights over resources. Burial mounds in the Midwest, are political and economic statements. A mound starts with a burial. As more burials are added, the mound gets larger. The mound, and its contents, is a visual signal. Burial in the mound is proprietary, so the presence of ancestor burials validates claims of historical continuity. The bigger mounds demonstrate longer and greater claims. Political units are defined by hierarchies of burial mound size.

In the Mayan area, temple mounds served similar purposes. Temples were built over at regular calendar intervals. The large late temples contain older temples. Each temple was a place for blood offering for a political group based on kinship. The relative temple size was a measure of political longevity in dynastic power. The large stone burial tombs in ancient Britain had the same purpose, visible statements of kin group history and control of a region: we are what our ancestors were, we are where our ancestors were buried ... your ancestors are not buried here ... you have no valid claim. The size of the burial complex relates to the size and longevity of the claim.

How important is material culture technology and/or style in these issues? Technology is just one aspect of human adaptation. There are technologies of production, technologies of distribution, technologies of consumption and technologies of storage.

Since human beings exploit all three environments, it is possible to expand storage “technology” through reciprocity by giving excess perishables to kin groups with the expectation that when similar excess occurs within their group in the future, you will get similar perishables back in return. This is a form of “technological” storage of information about an exchange and the debts incurred through such an exchange. Such technological forms may not appear in the archaeological record, but are real, and very common. Mentally mapping the environment, knowing its seasons and patterns, knowing where things are, and how to access them are all technologies. Sharing such information and expressing this information in complex cultural idioms is a form of technology.

I believe that the best way to create models for archaeology lies in an energy-information-economic paradigm based on general systems theory “firms” and an understanding of the “thermodynamics” of ecology. Thermodynamic demands of all living systems to exploit matter and energy and information for self-maintenance and growth (replication).

Models cannot cover “culture” (the idiom). We can model the technologies of production, distribution, consumption and storage. We can create models of adaptive strategies by modeling economic firms in relation to physical, biotic and cultural variables within a time sensitive population density. We can model the existing technological paradigm for production, distribution, consumption and storage systems.

Note that the models above are based on economic/adaptive variables. Change can come anywhere. It can be a matter of changes in the exploitive strategy and exploitive technology of production, distribution, consumption, or storage as part of the economic system in relation to variables in all three environmental sub-systems. It can come from a mix of any of these variables. It can come from changes in the cultural sub-system as well through manipulation of the cultural idiom. It can come from how cooperating human beings access and control valued resources.

Because humans can change, in fact, cannot help but change, and because human groups grow/expand (the normal process of all living systems), the cumulative body of change results in increased carrying capacity, increased levels of technology, and increased complexity of all types. This cumulative, noisy, sporadic and difficult to predict (specific variables) chaos does result in an overall trend towards increased complexity that we call human adaptation and cultural evolution. Change is complex and is constantly changing. No change is ever a change unto itself. Any change affects in some way every variable in a system, some more than others.

There is a technology of production tied up in a complex cultural idiom. There is a technology of distribution also tied to its idiom. There is a technology of consumption, again with its social idiom. There is a technology of storage, with its idiom. There is an idiom of investment. Production, distribution, consumption and storage are tied to physical resources and their idioms, biotic resources and their idioms, and cooperating as well as non-cooperating human resources and their cultural idioms. Any and all of these variables are subject to change (as a process) for access to, and control over, valued resources as a technology of exploitation and its related cultural idiom.

All of these complex variables are subject to mutual causal processes from feedback in non-linear convolutions impossible to predict or constrain. But since population growth is one key driver, and since systems can change to increase carrying capacity through technological change (and I include culture as a technology), there is a multi-linear drift towards larger, more technologically complex human systems over time.

The only thing that is certain is that overall populations on the earth have grown, and that groups constantly juggle the complex variables in all three sub-environments through a cultural filter rich in symbols and designed to be flexible. Group discussions constantly redefine relationships and interpretations in access to, and control over, valued resources. Vague symbolic terms allow diversity and reinterpretation under changing circumstances, demands and needs.

Complex systems are non-linear by nature and increasing complexity leads to increasing non-linear pathways with unpredictable outcomes. Culture is thus a dependent phenomenon of this manipulation and is isomorphic to the demands of living systems and the thermodynamic process. It operates as a filter between human beings and human groups. It contains latent values connected to matter, energy and information and access to, and control over, resources.

It is possible to create computer simulations of cultural systems. More complex models, however, increase the chance that the outcomes will not predict the real world process. Greater numbers of variable in a non-linear feedback system increase the chance for new and unpredictable outcomes. But with modularity comes an increasing chance at convergence. Each sub-unit has a large number of choices but choice in one is constrained by statistical choice in the others.

Ethnography describes and records culture and its patterns or traits. Ethnographers create summaries for thousands of individual decisions to characterize a cultural system. The results are an interpretation of a period of time for a specific group under general circumstance. An ethnographic study is a kind of “statistical” summation by the ethnographer, and different ethnographers may have come up with variations or quite different reports.

Computer simulations must also be models, and models must be simplified versions of real world processes. Models are only as good as their connection with phenomenal reality. The more complex the system, the sooner the model will diverge from real outcomes. Just look at any weather forecast program. Small differences quickly diverge in non-lineal feedback arrays.

Modular structure based on socio-economic firms is my suggested way to model human society. I am convinced it is possible to develop simulation models for described ethnographic cultures and to model artificial societies through this modular approach.

REFERENCES

[1] Buckley, W.F., ed.: *Modern Systems Research for the Behavioral Scientist*. Aldine Publishing Company, Chicago, 1968,
[2] Zadeh, L.: *Outline of a New Approach to the Analysis of Complex Systems and Decision Processes*. IEEE Transactions on Systems, Man, and Cybernetics **SMC-3**(1), 28-44, 1973, http://dx.doi.org/10.1109/TSMC.1973.5408575,
[3] Kosko, B.: *Neural Networks and Fuzzy Logic Systems*. Prentice-Hall, Englewood Cliffs, 1991,
[4] McNeill, D. and Freiberger, P.: *Fuzzy Logic*. Simon & Shuster, New York, 1993,
[5] Goldsmith, E.: *The Limits of Growth in Natural Systems*. General Systems **XVI**, 69-75, 1971.

MODULARNI PRISTUP RAČUNALNOM MODELIRANJU SUSTAVA KULTURE: KULTURA KAO TERMODINAMIČKI STROJ

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SAŽETAK

Kultura je kompleksni nelinearni sustav. Za računalno modeliranje sustava kulture potrebno ga je razdijeliti na podsustave. Ljudska kultura je modularna. Sastoji se od skupa ljudi koji pripadaju ekonomskim jedinicama. Pristup i kontrola materije, energije i informacije postulirani su kao ključni za razvoj simulacija kulture. Budući da su resursi u stvarnom svijetu sklopljeni, navedeni pristup i kontrola iskazuju se u dva povezana područja: ekonomskom (izravna kontrola) i političkom (neizravna kontrola). Optimalni način stvaranja modula za kulturnu ekologiju i ekonomiju slijedi iz paradigme energije-informacije-ekonomije opće teorije sustava kao i iz razumijevanja „termodinamike“ ekologije odnosno razumijevanja kulture kao termodinamičkog stroja.

KLJUČNE RIJEČI

kulturna ekologija, termodinamika, teorija sustava