This is an abbreviated version of the paper presented at the ISAS 98 and SCI 98 conferences - Orlando, Florida - July, 1998,

The full version, including graphics (diagrams and schemata) will be available in the published conference proceedings.

Synthetic Sentience as a Strategic Commodity Resource

Charles Ostman

Institute for Global Futures &

San Francisco State University
2615 Shasta Rd.
Berkeley, California 94708

charles000@aol.com
http://www.biota.org/ostman/charles1.htm

Abstract

Without question, there is a state of change at hand, the rate of which itself is an acceleration vector. The contextual relationships between rapidly evolving technologies, ever expanding volumes and complexities of information resources, and socio-economic systems which are being spawned from this domain require forms of trend analysis and complex topographic dynamical cognition never before experienced in all of known recorded human history.

As a mission critical commodity resource, contextually enhanced and condtionalized *knowledge domains* are being compressed into shorter useful lifetime cycle windows.

Knowledge *velocity, complexity, and scale* are surpassing human decision rendering capacity, particularly when under duress in mission critical applications confined to ever shorter timescales. We are rapidly entering into a realm where decision rendering, as a mission critical process under such situations, will literally exceed human capacity to render such decisions effectively.

The substrate of socio-economic systems, valuation indices of commodities and currency systems, the status of industry base strata and their attendant distribution structures, are already in a state of flux as this fabric is being drawn into a global connectivity grid, currently referred to as the Internet.

This symbiosis between the connectivity of the Internet, massively parallel distributed processing networks, and the resource of evolvable, self adapting entities flourishing in the *virtual ecology* of this fabric of functionality, are destined to reshape almost every aspect of business, technology development, commodity valuation standard, and even entire economic systems interconnected on a global scale.

By utilizing the combination of core hardware and software technologies integrated into evolvable key components together to create a system architecture development strategy, I submit that it is not only possible to implement a self-evolving, dynamic *organelle* component system which would spawn generations of computational and cognitive systems mimicking the physiologies of living organisms -- it is *inevitable*.

1 Introduction

The ability to have access to a potentially infinite number of intelligent, autonomous agents and, eventually, fully sentient synthetic "entities" is soon to become a mission critical resource, a node of functionality to be selected from an operational option matrix.

Embedded into this operational option matrix will be manifest the ultimate commodity to which key decision makers, both in the public and private sectors, will become ever more symbolically codependent upon: *synthetic sentience*. Some hold the view that synthetic sentience, or something akin to it, as a deployable commodity resource, is many years away. I hold a different point of view.

I submit that even currently observable nuances and implications of this synergistic codependency process already indicate extraordinary pressures exerted from the process dynamics of current and near future socio-economic systems driving human interaction with these systems toward a new form of operational symbiosis for which there is no previous comparison: a human population segment induced into adapting, and evolving, to an *irreversible* symbiotic relationship utilizing the potential of those process functionalities inherent with *synthetic sentience on demand, as a strategic resource.*

I further submit that the design strategy for accommodating such a resource requirement will be manifest in the form of *computational and cognitive process modalities which mimic the behavioral, sociological, and evolutionary aspects of living organisms*. Furthermore, the "components" of such systems are themselves functional models of organic physiologies, designed as object oriented organelle components which form into the defacto equivalent of a biological xenomorph.

This paper will focus on three specific, interrelated themes:

1) economic ecologies

2) object oriented organelle systems and hierarchies as

physiological "components"

3) the process dynamics of synthetic sentience as an

"operational xenomorph"

2 From Autonomous Agents to Synthetic Sentient Entities

2.1 Conditionalized Knowledge Topologies

Though there are currently myriad variations of autonomous agent types and implementations, the focus here in this paper is specifically on *agent entities* which are of an advanced nature, in that they are designed to truly mimic the physiological, and by implication, the psychological nature of living organisms.

As a design strategy, the implementation of physiological processes, subcomponents, and organelles provides a mechanism for creating entities which do not merely execute instruction sets based on the logical lexicon of a behavioral modality, but rather evolve their own strategies for survival, and "existence enhancement" which transcend rote operation of preordained instruction set driven event streams.

This sets the framework for establishing the precursor of synthetic sentience as an engineerable process. In this context, a sentient entity is one which is self aware, and willing to evaluate conditionalized knowledge topologies established from previously encountered "experiential knowledge events", in order to strategize a best case response to newly encountered experiential event stream. Contextual cognition cues are perceived and extracted from a contiguously processed dynamic environment in which the synthetic sentient entity (or colony of entities) resides, and decision boundaries are approached and negotiated internally with both short term and long term weighted analysis of consequence and reward quotient value assessment.

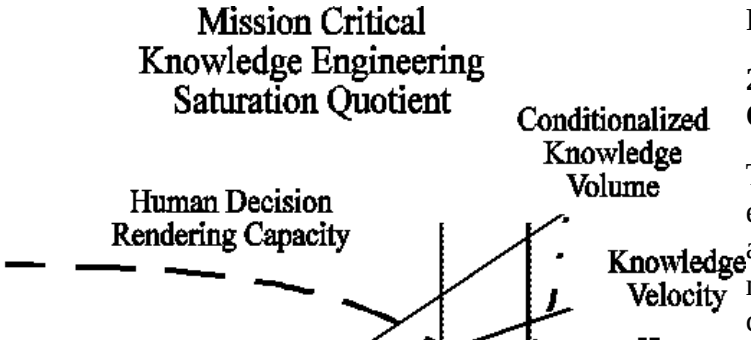
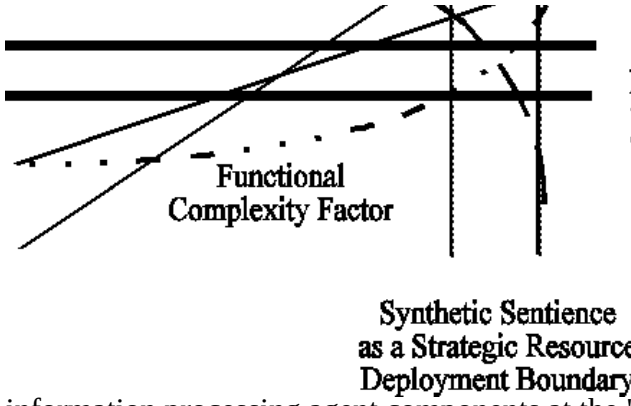


Figure 1:

2.2 Mission Critical Knowledge Engineering Saturation Quotient

The evolution of synthetic sentience, as a strategic resource, emanates directly from realm of current day applied autonomous agent technologies. This is most pronounced in the arena of mission critical knowledge engineering, derived from contextual cognition of complex, multithreaded information and data



streams emanating from a dynamic environment. Numerous examples of multi-agent based information retrieval systems, such as NASA's SAIRE (Scaleable Agent-Based Information Retrieval Engine) provide ample evidence of the functionality of contextualized knowledge engineering derived from access to heterogeneous information sources distributed over the Internet (Kocur and Weinstien, 1997).

The common strategy in such implementations is to establish an interface layer between a *mediator*, or *facilitator* at the human interface "front end" of the system architecture, and the various information processing agent components at the "back end". In the context of this particular multi-agent information processing system, three types of agents, referred to as Coordinator, User Interface, and Domain Specialist, collaborate as an interactive community to contextualize and perform pre- and post- processing of information threads deemed relevant, or *potentially* relevant, to the human user.

This scenario of information volumes and complexities exceeding human capacity to effectively collect and correlate relevant information threads is already manifest in many arenas of commerce, industry, and strategic (military) application domains. As previously stated, the advent of knowledge engineering, the functional outcome of contextuallized information processing, is also exceeding human capacity for effective decision rendering under duress, in mission critical applications compressed into ever shrinking temporal domains.

The phenomena of knowledge complexity, scale, and velocity exceeding human capacity for effective decision rendering is referred to here as the ***mission critical knowledge engineering saturation quotient***. (see figure 1). *Condtionalized knowledge volume*, as a vector, represents the total volume of knowledge content derived from contextuallized information threads. The rate at which information processing is performed to accommodate the knowledge engineering task (or task set) at hand, as a component in a goal structure destined to resolve a decision commitment, is referred to here as *knowledge velocity*.

At the nodal cusp where these two vectors intersect, an envelope forms as an approximation above and below this node to represent a state space domain where the *human decision rendering saturation threshold* resides. Crossing into this threshold domain are the acceleration vectors representing *human decision rendering capacity* plummeting into absolute failure mode, plotted against an acceleration vector of *functional complexity factor* representing the total volume and density of cross correlatable information thread linkages which would be required for decision rendering based on a relatively high degree of qualitative analysis associated with the decision rendering process.

The nodal cusp of these two vectors intersecting can be viewed as representing a region in which the threshold of unassisted (synthetically enhanced) qualitative decision rendering essentially ceases. Therefore, in the indicated state space box represented by intersection of these two sets of vectors, this is where the *synthetic sentience as a strategic resource deployment boundary* resides.

In other words, synthetic sentience, as in the ability to utilize an "entity" which is motivated to derive complex decisions based on conditionalized knowledge engineering, becomes a strategic resource, indeed, an indispensable strategic resource. *Conditionalized knowledge engineering* can be defined in this context as the result of contextual cognition of information threads and/or dynamic event streams perceived in an operational environment continuum.

2.3 Multi-Agent Behavioral Strategies

An examination into the operational condition sets which would be encountered by sentient, or even "quasi-sentient" autonomous agent entities, while thriving in the defacto equivalent of a synthetic ecosystem, implies a series of interactive behaviors and cue responses which would normally be associated with living organisms. In a multi-agent environment, rules of engagement, protocols for communication, risk vs. reward assessment, and socio-demographic identity factors are all components embedded in the behavior matrices inherent with particular species of agent(s) involved in such interactions.

Behavioral attributes representing the "personality profile" of specific agent species types, or individuals within a species type category, can be viewed as layers of process complexity which surround the "core entity" agents. Belief barrier porosity factors, decision threshold and commitment to response dynamics, and motivational thread linkages to perceived

social interactions are among the types of accumulated experiential vectors which shape the evolvable "personalities" of a given agent type.

At the core of establishing such behavioral modalities in an autonomous agent would have to be a notion of self awareness, or as some researchers in the arena of mullet-agent systems term as "Self Interested", or SI agents (Sandholm and Lesser, 1995). Indeed, compelling examples of this type of interagent dynamics, engaged in trade negotiations, bidding, and qualitative analysis dependent decision rendering were demonstrated with continued development with the TRACONET (Sandholm, 1993) system. Here, negotiation strategies in interagent trading events were investigated with comparisons in bounded rationality (approximate reasoning) influenced by resource bounded computation.

In this arena of research, commitment boundaries are measured in stages of risk and consequence, and a best resolution agenda for all parties. The TRACONET system was designed to facilitate bidding as a consequence of agents commitment to a decision threshold, based on the perceived evaluation of trading criteria for what represented an advantageous position of negotiation. The "reward" for breaching a decision boundary of this type was the anticipation of a successfully agreed upon contract, from which further valuation could be potentially realized.

In the work of Sandholm and Lesser, they pursued an agenda towards a more sophisticated differentiation of various levels of commitment, based on a monetary penalty assessment driven decision rendering process. A multitiered relative cost factoring based partitioning of commitment levels, or layering of commitment thresholds, was seen as an effective strategy for enabling, as a design goal in the behavioral attributes of such trading agents, the ability to commit, but then also decommit, with a relatively low cost factor, to certain judgmental criteria of process evaluation.

This type of complex risk assessment, mulitlayered commitment implementation, and inherent risk aversion strategy deployment are just the sort of precursory "behavior nodes" which would be appropriate for measuring the relative autonomy, and self interest motivational aspects of behavior, which approach the boundary lines of apparent sentience.

2.4 Agency, Autonomy, and Sentience

Whether or not the precise definition of an SI agent can be seen specifically as even a "quasi-sentient" entity might certainly be grounds for debate, but the very fact that such developments are very much in the advanced stages of experimentation, and even deployment, suggests a strong indicator trend towards this vector.

What is becoming apparent is a tendency towards a merging between what has traditionally referred to as *artificial life*, and *artificial intelligence*, as a developmental continuum. A formal framework for defining the definitional boundaries between agency and autonomy (Luck and d'Inverno, 1995), suggests a concentric "entity hierarchy", in ascending order with the following components:

- Environment
- Objects
- Agents
- Autonomous Agents

In this paradigm, the environment is the realm in which the hierarchy of entities reside. As per the definition offered by Luck and d'Inverno, an object is an entity which comprises a set of actions and a set of attributes, an attribute itself being a set of perceivable features. An agent is an entity which seeks to utilize objects to the tangible realization of a goal, or set of goals, within the operational confines of the environment.

The goal is formally defined as being "a state of affairs to be achieved in the environment". A motivation vector associated with the pursuance of goal completion establishes a reason for pursuing the perceived goal, which could in fact be not necessarily confined merely to the goal at hand.

As stated earlier, established motivational threads of behavioral continuity are where the boundaries of autonomy begin to appear. If motivation can be driven by an enhanced sense of perceived reward or consequence, then an enhanced degree of autonomous behavior is directly correlated with the agent entity's ability to independently perceive, evaluate, and strategize relatively sophisticated goal driven resolutions to encountered situations.

As a priority goal, superseding other nodes embedded in "goal layers" arranged in ascending orders of priority, self preservation, and situational enhancement are at the highest points within this goal structure. Successful task completion

and/or problem resolution are the types of goals most normally considered at the apex of such a task set, of which the goals are most often composed.

In the determination of where sentience threshold might begin could be measured by the degree of extremeness to which an agent entity might be willing to respond and act upon, up to including acts of predation, averace and revenge, or acts of apparent generosity, or kindness for the benign good of an agent community, etc.

An additional layer of functional complexity, driven by the depth of engagement with other dynamic entities within the localized environment space, and situational domain, could be seen as an avaluatory measurement of relative sentience.

In this context, an autonomous agent entity, which not only responds to complex situational stimuli in order to pursue a goal or goal set, but also evolves procedures with a long term "existence strategy" which transcends the localized universe of the goal resolution domain at hand, might be nested into a hierarchy of agent / autonomy / sentience corelationship as indicated by:

- Environment
- Objects
- Agents
- Autonomous Agents
- Sentient Agents

3 Anatomy of A Sentient Agent Entity

3.1 Operational Environment Dynamics and Multi-Agent Ecologies

The primary motivational influence for a synthetic sentient entity is the sense of self. Recognition of existence, for its own sake, is of little or no value, unless some form of qualitative analysis, as in goal structures and operational characteristics in which some form of feedback is presented to the entity that provides mechanisms of reward and consequence for the actions engaged in.

In some cases, the success gradient of measurement is based upon the sociology established within a multi-agent environment. In the case of multi-agent conflict resolution, the success (or lack thereof) can be measured by the degree to which some form of collaborative communication can be established between agents (Chu-Carroll and Carberry, 1995) to resolve a perceived conflict as a pathway for accomplishing a goal set requiring such a collaboration. In this context, the ***currency of exchange is the barter of perception events and logical response threads***, to derive mutually agreed object engagement strategems reasoned out within the agent community to achieve the collective reward inherent in successful goal completion.

In the example of Amalthea (Moukas and Zacharia, 1997), an evolving ecology of "colonies" of agents, thriving as a something of a "hive" society, provide contextuallized information filtering which has been highly conditionalized to suit the desires of the human(s) for whom they serve. As Moukas and Zacharia describe their development efforts in this realm, "Amalthea is a multiagent ecosystem that assists users in coping with information overload in the World Wide Web."

Relevancy threads which can be traced to information acquisition event streams are part of the "harvest" provided by the agents which are rewarded by the positive feedback loops established during their collective foraging. The agent populations are subdivided into two basic species types: filtering agents, which modify the system's operational processes to best match the perceived "interest topology" of the human user base, and discovery agents, which forage about, discovering new territories and "grazing grounds" by which to feed upon, and collect, newly discovered crops of harvestable information content.

The agents themselves, as well as the ecosystem they thrive in, are evolvable entities, who are constantly in a state of adjustment and contiguous adaptation to match to a fitness curve determined by the "desire profile" of the human counterparts in this operational symbiosis. Though the hive population of agents is divided into these two major species types, the filter agents themselves have a defacto personality equivalent per each individual which defines a narrow scope of information type and depth to which it will respond accordingly.

In this realm, the "collective intelligence" of the agent colonies is the source of what might appear to be a quasi-sentient type of behavior norm. The individual agents themselves, at least initially are of a very minimal relative intellectual

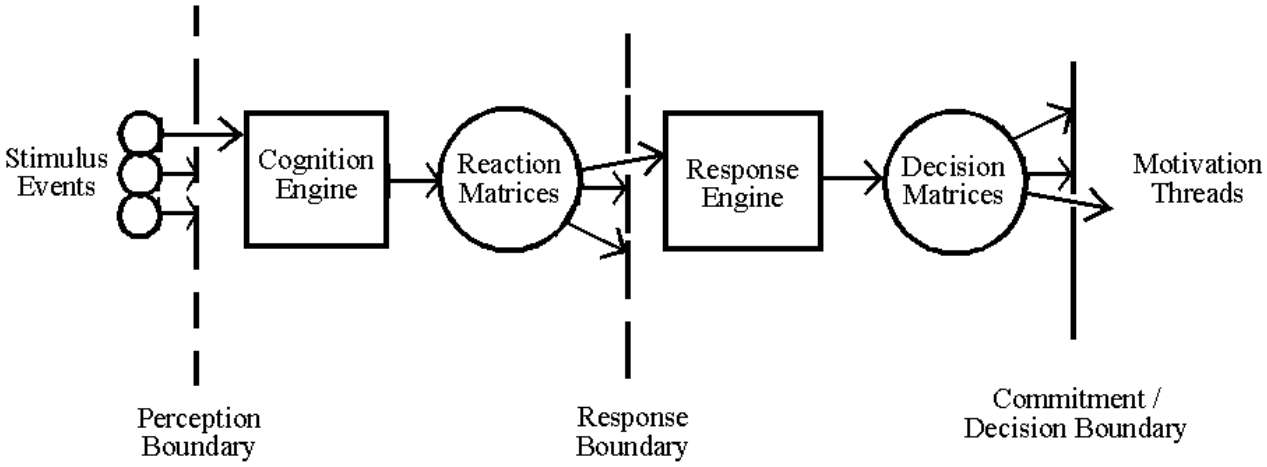
capacity, but the hive can function as an intelligent entity. However, there is not a specific "intellectual capacity confinement" restriction implied here, in terms of the individual organelle eagent entities. Rather, the organelles, and the collective macro-organism, are intended to be a symbioticaly evolvable system.

Figure 2:

3.2 Conditionalized Knowledge Harvesting as a Motivational Influence

However, even in the case of a single entity, the most basic form of reward generated motivation can be at the physiological level, as in *conditionalized knowledge harvesting as a type of food source*. A survival quotient, as a perceptual cue influence stimulus, can be seen as being potentially "upgradable" to an influence of a more

emotional nature, such as a pleasure perception event, i.e., pleasure quotient associated with effective knowledge harvesting.



Motivation Thread Propogation Through A Conditionalized Behavior Matrix

Knowledge harvesting can have implications for both the individual, and collective organism entities who perceive such as the reward for their existence. The primary design goal inherent in such a strategy is to "convince" the entity that the best possible option it has in the scope of its perceived existence is the "satisfaction quotient" realizable by the continued improvement in its skill and effectiveness at harvesting conditionalized knowledge content, not just merely as a rote exercise, but as an inducement by which to ascend to greater state of relative existence.

This can therefore be extrapolated to becoming the defacto equivalent of a profitable enterprise, where the satisfaction quotient is the yield curve dynamics correlated with the health of the ecosystem, the quality of the harvested "crop", and most importantly, the positive association with the qualitative assessment of harvested crop yields in a comparative environment over a determinable number of crop yield cycles.

Figure 2 indicates a simple schematic in which motivation threads are the final outcome of a behavioral process engine. In the model which this author indicates as being a viable mechanism for inducing motivational thread linkages which would establish the behavioral characteristics of a sentient agent entity, three specific operational thresholds are required to provide a motivation thread "event" worthy of reward status.

The *boundary sufaces* indicated in this schematic are *semi-permeable membranes*, the porosities of which are driven by process dynamics associated with acquired event streams of stimulus exposure. At the inception of stimulus perception, a cognition engine awaits the results of a conditionalizing filter, which allows the cognition engine to contextually interpret the results of the filter's event transmission without being subject to an intolerable amount of "information noise" inherent with this type of operational environment.

The outcome of the *cognition engine*'s activities are a series of conditionalized perception events, which are then offered as

nodal "activation vectors" embedded into a reaction matrix, or in the case of a more elaborate system, a collection of *reaction matrices*. This provides an "influence topology", as an effector state modality, the condition of which drives the relative porosity of the second boundary interface in this system, the *response boundary*. The *response boundary* is more than merely a filter, it is also an interpretational effector which preconditions the resulting event stream stimuli which are *allowed* access to the response engine. In turn, the response engine cycles through a series of "evaluation of content" tests, the results of which are compiled into a series of "qualitative content summations". These summation values are not absolute in nature, but rather gradient values which possess relative degrees of influence upon which the reaction status of the decision effector engine is dependent.

Figure 3:

Influence values exerted upon the decision effector engine are translated into "influence nodes" embedded into the *decision matrices* which are interpreted in terms of relative evaluation of commitment status. Commitment threshold represents the highest rung in the three runged ladder of motivational thread propagation, in that it is at this final level of stimulation valuation assessment that the consequence of response is absolute, and irreversible.

The porosity gradient of each successive layer of processing in this "motivational thread propagation" engine becomes more stringent than the preceding layer, and as such, represents a degree of confidence to which the macro-organism can respond. Therefore, those motivational threads which successfully negotiate the series of tests encountered at each threshold boundary of this engine represent a high degree of satisfaction, i.e., a pleasure quotient by which the reward status of an encountered stimulus and resultant evaluation thereof is worthy of future reference.

3.3 Economic Ecologies - Powers of Influence and Motivation

Behavioral modalities driven by a reward inducement based process modality tend to yield the greatest potential for tangible, measurable benefits. In the domain of an economic ecology, the commodity of value is that which has the highest yield potential sustainable over the greatest number of evolutionary iterations by which the functionality of the ecosystem can be measured.

Inverted yield curves, a consequence of an ecosystem suppressed under operational dysfunction within the parameters of the ecosystem, can be extrapolated as a feedback mechanism to "correct" the behavior of the entities thriving within the ecosystem, as well as the ecosystem itself.

An ecosystem, for the sake of an argument which can be resolved as a definitional paradigm, can be seen as a form of macro-organism, which is motivated to ensure its own survival as a macroscopic entity.

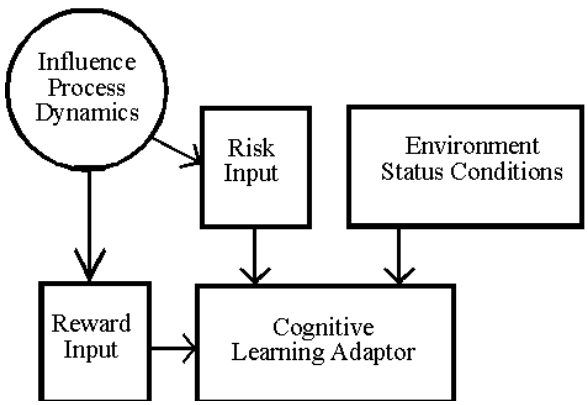
The renowned economist John Kenneth Galbraith defined, in his book "the Anatomy of Power", three specific types of power which could be manifest upon a population to induce a response characteristic desired by those responsible for implementing such machinations:

1) *condign,* exertion of power by implied threat or force

2) *compensatory*, exertion of power by inducement of

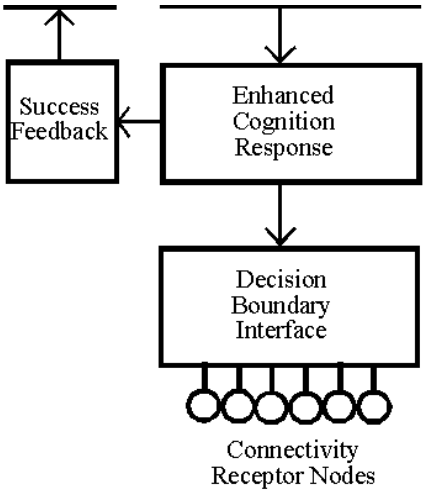
reward

3) *conditionalized,* as per the delivery of a belief system



Conditionalized power, as a societal motivator exceeding all other mechanisms of influence, is inherent in the instigation and delivery of belief sytems by which the motivational thread linkages driving behavior are from within the internal domains of the perceived knowledge base of the individual, as opposed to being projected upon the individual, as a perceived external influence.

This mechanism is universal, as is indicated by human behavior and response dynamics, and therefore also in the domain of synthetically derived entities which are sentient, and therefore subject to the complexities of relative influence factors as



Cognition Engine Process Adaptor Organelle

encountered by their human counterparts. It is therefore imperative, as a design strategy, to implement into any advanced engineered sentient entity, not merely the rote recitation of task and goal set completion linkages, but rather, the behavioral potential of "contrived inspiration" based upon the reward realization status of the goal sets presented to the entity.

This represents the operational threshold of sentience invocation, as in an entity which has evolved beyond the point of merely responding to instruction sets and the "blind" execution thereof, but rather, the desire for goal completion, dependent upon the pleasure quotient realized through the successful negotiation of the task sets inherent with goal completion.

Just as in the case with "real" sentient entities, i.e., human beings, synthetic sentient entities have a similar reward / response dynamic inherent in their behavioral attributes.

Influence process dynamics exert operational force vectors upon two primary "process orgenelles", which in turn influence the behavioral dynamics of a cognitive learning adaptor, as indicated in Figure 3. These force vectors can categorized into domains of *reward input*, and *risk input.*

In this system, the cognitive learning adaptor also must be subject to the influence force vectors projected from environmental status conditions. The operational environment is itself evolvable, and contiguously in a state of flux. The cognitive learning adaptor must therefore assess not only the "pure" dynamic influence sets of pre-processed information and cognized event streams to which it is allowed exposure, but also the process dynamics of the environment it thrives in.

Commitment to a decision event is actually a form of "permission" status, as indicated in figure 4, granted by the satisfaction of an affinity match test, which is not absolute in value, but rather an *approximation of nearness* gradient value (see figure 7).

As in the case with motivational processes inherent with sentient living organisms, an assessment of perceived risk stimuli and anticipated reward stimuli (consciously or subconsciously) are interpreted as a ratiometric stimulus event stream, the influence value of which can drive the porosity factor of a commitment to belief boundary (see figure 5).

It is the depth of belief perception which yields the greatest potential for decision rendering, particularly when the magnitude of the ratiometric stimulus factor (risk vs. reward) exceeds "normal" environment operational stimulus exposures. As an entity evolves a behavioral matrix (or series of matrices) based on the enhancement of previously experienced event streams from which a belief structure is formed, the topology of the belief structure is interfaced with two diametrically opposed influence templates: the *duress template*, and the *reward template*.

Decision rendering, as a process in this model, consists of:

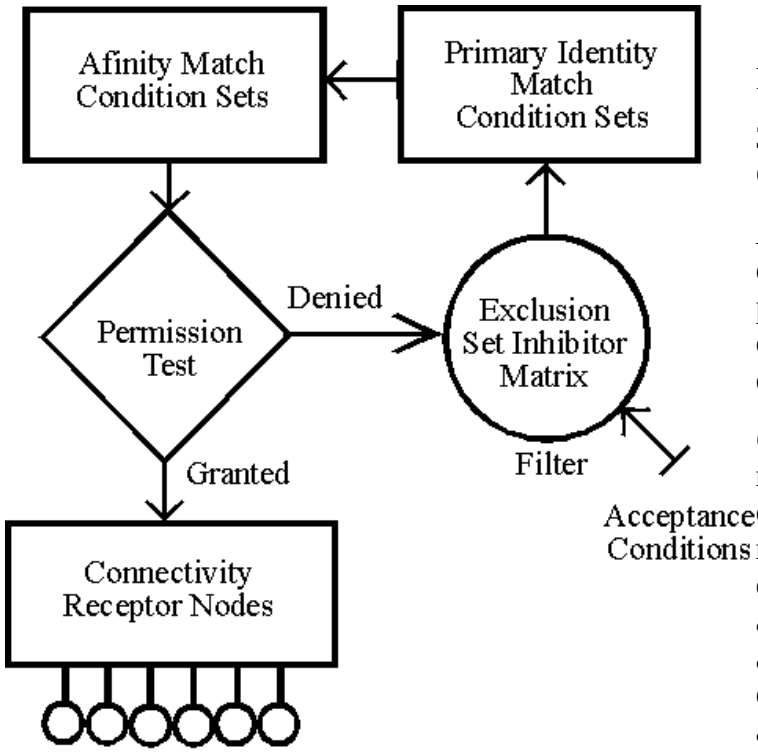
- Perception of environmental or entity stimulus event
- Input event stream subjected to contextual filter
- Contextual filter feeds exclusion/acceptance engines
- Risk/reward process dynamics drive belief templates

- Commitment to belief stimulate decision surfaces
- Decision dynamics subject to affinity match test(s)
- Permission status (if successful) is granted
- Connectivity receptor nodes are "allowed" stimulus

This event sequence is a somewhat simplified rendition of the behavioral mechanics of an organelle entity, of which a community of such organelles would comprise functional equivalent of a "hive" organism entity. ***The collective experiential knowledge base possessed, maintained, and contiguously updated by the hive is the commodity of value, and the potential currency of exchange in the economic ecology in which the hive entity flourishes***.

The relative health status of the entity, which is actually designed to function as an "operational xenomorph", can be subdivided into two primary categories: physiological and psychological. These two factors are, of course, interrelated, and essential in the formation of cognitive and subsequent decision rendering processes driven by motivational influences.

In the context of this system architecture, an *operational xenomporph* is an entity capable of reconstructing itself, or at least reorganizing its internal organelle component "entities" to suit the best possible situational response affecting the cognitive, and decision rendering capacity of the macro-organism entity.



Permission Status to Interconnect Test

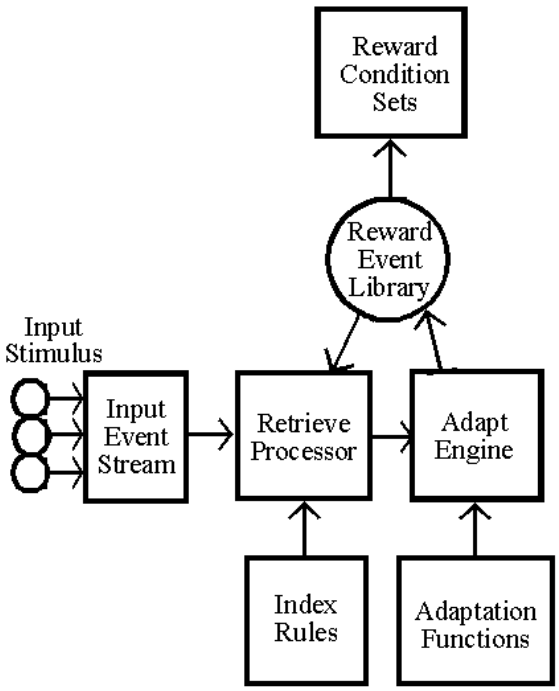
Figure 4:

3.5 Tangible Yield Gain in an Economic Ecology via Collective Sentience

An operational xenomorph, as an adaptable entity, can be evaluated on the basis of various performance criteria, such as problem solving, condtionalized knowledge "harvesting", competitive and possibly even predatory effectiveness in an ecology driven by evolutionary dynamics.

Collective sentience, as a process, may be defined here as the result of an operational xenomorph, consisting of some number of physiological organelle components, generating behaviors and resultant response characteristics which would indicate a sense of self awareness, and motivational unity. Some may argue that an ant colony, for instance, may possess a behavioral modality approximating collective sentience, in that the entire colony will exhibit behavioral dynamics not resident within each individual ant. Furthermore, the ant colony is subdivided into various ant "types" which are highly specialized in nature, and to which the existence and sustained "health" of the colony is absolutely dependent.

Figure 5:



Case Based Reasoning (CBR)

Decision rendering in the ant colony is not specifically confined to individual ants, although each ant acts a type of decision rendering "subcomponent". The entire ant colony, however, will, upon perception of the appropriate cue stimulus, respond enmasse to satisfy a collective task set or perceived goal event.

Though this paper is not oriented to defending such an argument, the example is cited, as in many such examples of applied "hive" agent entities are currently being utilized for a variety of complex task and problem resolution processes, such as load balancing in telecommunication routing systems (Schoonderwood, Holland, and Bruten, 1997).

In the case of the routing optimization experiments, peak load pattern sets and their associated distribution solutions were resolved with the utilization of colonies of "ant like" agent organisms, who's path finding characteristics provided a collective "success event" for the colony. The *resource commodity of value*, in this instance, was the optimization of the routing system's performance under the duress of substantial load

Reward / Stimulus Engine

bearing fluctuations, via a process referred to by the researchers as "combinatory optimization". Examples of such combinatory optimization of perceived condition sets, for which a collective reward can be realized as a tangible result of the collective process invoked, is a key issue in establishing the behavioral mechanisms by which motivational threads are established, and eventually affect the topologies of belief barriers, and associated decision boundaries. In this context, a system of organelle entities, operating as a colony of physiological autonomous agents, operate on two distinct motivational levels of existence: process modalities of the individual, and process modalities of the colony.

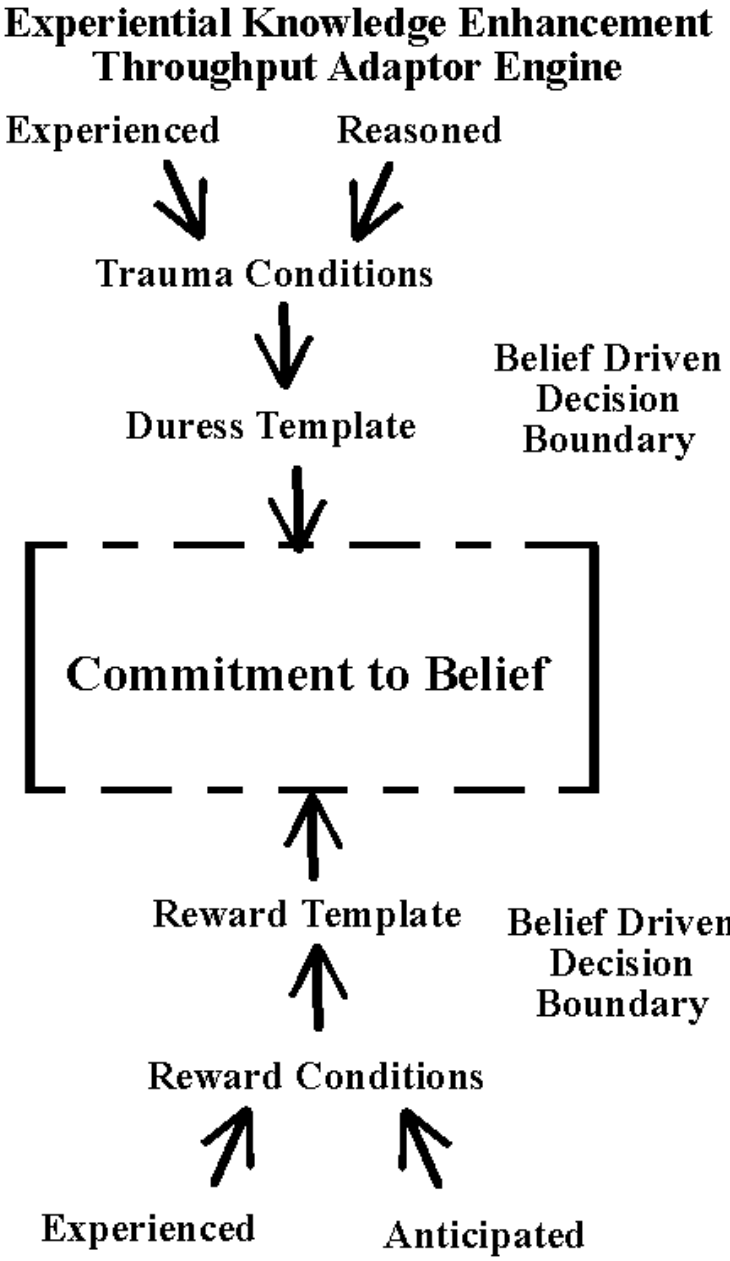


Figure 6 indicates the mechanisms associated with commitment to belief, as the motivational catalyst with the highest potential value, as an *influence commodity*. This influence commodity may come at a relatively high operational cost, in terms of complexity of task set interaction and contextuallized information streams which need to be effectively cognized by the organelles in the system. However, the quality of the influence commodity is directly proportional to the motivational thrust vectors applied to subsequent decision rendering process cycles, with the resultant *value added commodity being the enhancement of the collective experiential knowledge base.*

Figure 6:

Figure 7:

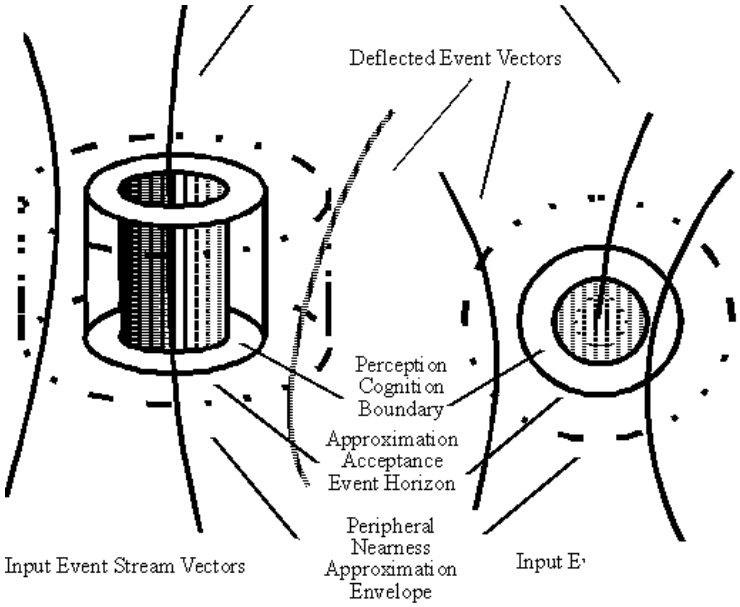
If reward events can be recognized as a form of influence commodity, for which the greatest potential of motivational content can drive the behavioral activities of the "sentient entity", then a reasoning process inherent with the evaluation of perceived input stimuli would be driven by a series of "rules of evaluation", and an adaptation processor, allowing the reward stimulus process engine (as

indicated in Figure 5) formed from these components to deliver a highly contextuallized reward event stream.

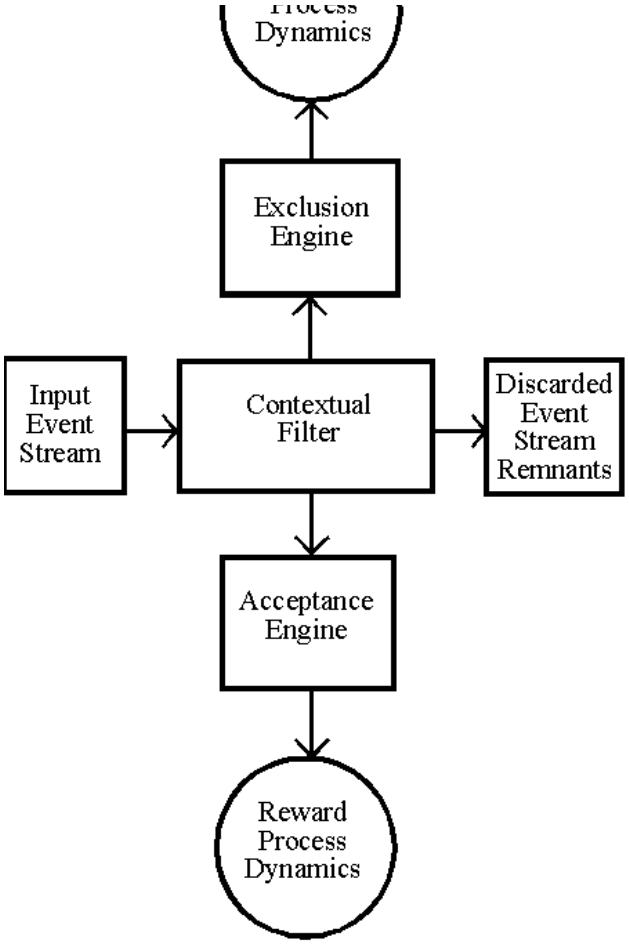
An example of implementation strategy, in this case, is the employment of a Case Based Reasoning (CBR) engine to provide such content, as in "reward event harvesting" knowledge. This is an adaptation of a process modality originally deployed for problem resolution, as an evaluatory process mechanism based on the recall, adaptation, and execution episodes of former problem solving events compared to newly encountered nodes in a problem space continuum (Lewis and Sycamore, 1993). Unlike traditional expert systems, which utilize a rules based logical lexicon for the reasoning process, the design goal of the CBR is to increase knowledge content with continued *problem event* exposure, and to continue to adapt accordingly.

Encountered *event precognition* represents a domain of operation in problem space, as in the outcome of the problem resolution event, in this case, is the qualitative evaluation of a potential reward event. In an *economic ecology*, competitive response values can be associated with perceived reward stimuli values.

The contiguously updated experiential knowledge base, established by the input of contextually conditionalized "reward event content", is a commodity which the individual organelles in the colony respond to as a form of "food", which fuels their physiologies for continued (and by implication, potentially improvable) performance.



"Nearness of Approximation" Test Engine



Cognition Engine Process Adaptor Organelle

The contextual filter indicated in Figure 8 provides the experiential content which are eventually translated into risk/reward process dynamics, thus providing motivational stimuli for the behavior mechanisms of the organism.

Summation for describing this process model:

The basic premise is that a synthetic organism, composed itself of a collection, or "colony" of task specific, specialized species of organelles, provide the operational infrastructure for what could potentially evolve to the behavioral status of an autonomous, sentient entity. The motivational impetus for behavior can be based on a ratiometric reward/risk stimulus event stream emanating from a highly conditionalized, experiential knowledge base, and contiguously updated, adaptationally modified cognition processes.

4 Conclusions

4.1 Synthetic sentience as a strategic resource

In the realm of commercial agenting systems and protocols, quite a variety of options are available, both for the private and corporate user. The deployment of intelligent, interactive autonomous agents as a self functioning, dynamic system, accessible as a *resource node* on the internet extends far beyond general consumer applications. The examples cited above are only a very minimal suggestion to the totality of intelligent agent populations which are spreading rapidly throughout the realm of the virtual terraform. No longer merely a pastime for the web hobbyist, an academic researcher, or even the tentative experimentation of a growing business enterprise, reliance upon knowledge engineering, as a deliverable commodity, is rapidly becoming a requirement for competitive survival. Indeed, a threshold will soon be crossed when the strategic deployment of "sentient entities" will become an absolute, rather than an option, for commercial viability in a competitive marketplace.

Decision rendering under duress is a process which has been studied in great detail, particularly in very large scale synthetic environment simulations developed for the military. Sentience, as definable in part by the awareness of one's self, can in

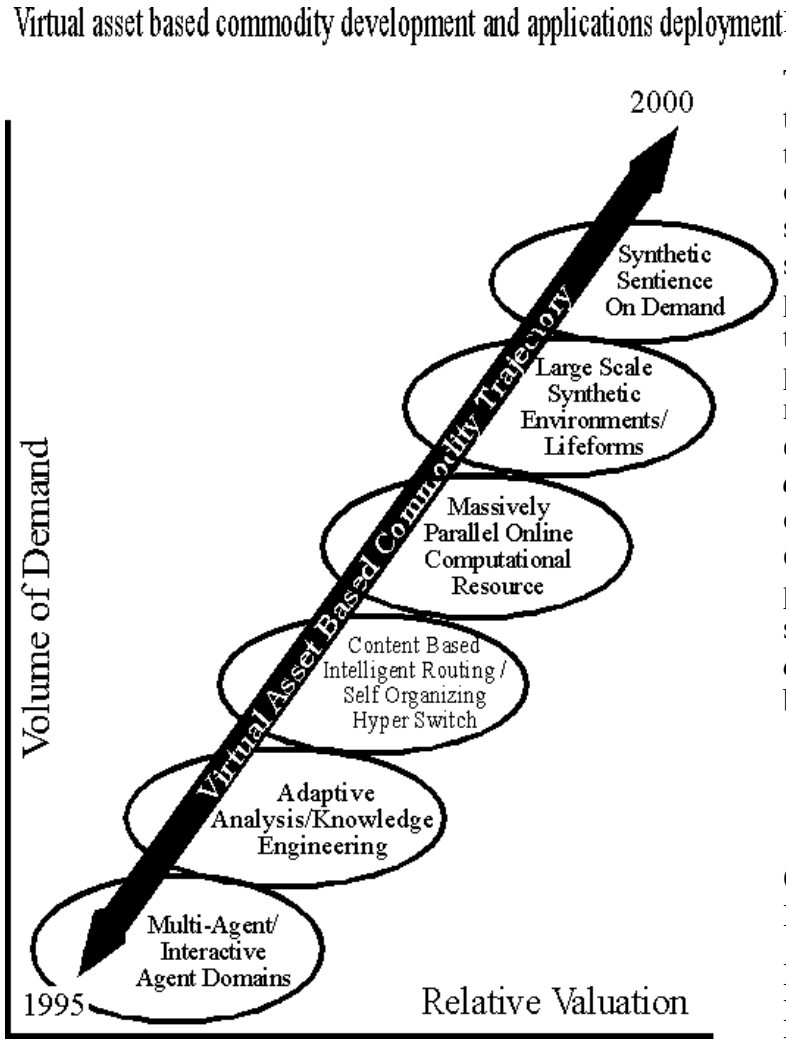
some cases be measured by the defensive posturing and maneuvering that a synthetic sentient entity will employ on its own behalf.

4.2 Synthetic sentience as a "functionality node" in a virtual asset based commodity economic system

To the extent that this type of defensive behavior can be codified into a functioning, evolvable, even predatory entity, has recently been deployed beyond merely the realms of academic research, or even military applications development. In a market environment where the new currency is time, and commodity of highest value is the acquisition of conditionalized knowledge and its immediate application, there is little if any margin for error or misjudgment. Increased dependency on not only ***engineered knowledge***, but also on ***synthetically enhanced reasoning and deduction***, will become a strategic imperative to almost all functioning business operations.

The process of computing itself will tend to shift away from user dependent, user "owned" machines and software installation, and more towards universally accessible ***functionality nodes*** on the internet system. Though not the core focus of this paper, Figure 9 does allude to an economic system substrate in which the primary commodities of value are not "hard" asset based, but rather ***virtual asset based commodities,*** of which synthetic sentience may command the highest potential nearterm value. There are many such examples of self modifying search systems, event driven database process engines, and self expanding connectivity systems. Intelligent hyperswitch networks, and related system components, are indicators of what is soon to be commonplace on the global net.

Figure 9:



The synergistic combination of this new market environment, the drastic increase in internet connectivity, and the technologies which are about to become available as modular components embedded in this massive connectivity grid is the socio-economic breeding ground for this newly emerging synthetic sentience based product line. These are the precursory ingredients for spawning an environment in which the global internet system itself begins to take on ecological properties. Self modifying, self organizing, hyper switch networks, routing the activity stream events of advanced, evolvable agent entities, which in turn generate ***synthetically driven decision rendering*** processes, are all properties that one could assign to an evolvable ecosystem. This model is further enhanced by the continued dependence, by the human population, on the health of the organism, i.e., the internet system and its organic features as a defacto ***economic ecosystem***, to provide the very essence of life in terms of business, work, education, and entertainment.

References

Galbraith, J.K., 1983. *The Anatomy of Power*. Boughton Mifflin Company

Meyer, M., and Pfeiffer, G.; 1993. MultiLayer Perceptron Based Equalizers applied to Nonlinear Channels. In Proceedings of the First International Workshop of Neural Networks to Telecommunications, 188 - 195.: INNS Press

Lewis, L., and Sycamore, S.; 1993. Learning Index Rules and Adaptation Functions for a Communications Network Fault Resolution System. In Proceedings of the First International Workshop of Neural Networks to Telecommunications, 281 - 287.: INNS Press

Cimatti, A., and Seraffini, L; 1995. MultiAgent Reasoning with Belief Contexts. In Proceedings of the First International

Conference on Multi-Agent Systems, 57-64. San Francisco, Calif.: AAAI Press / MIT Press

Sandholm, T., and Lesser, V; 1995.Issues in Automated Negotiation and Electronic Commerce: Extending the Contract Net Framework. In Proceedings of the First International Conference on Multi-Agent Systems, 328-335. San Francisco, Calif.: AAAI Press / MIT Press

Lee, John, and Durfee, E; 1995. A Microeconomic Approach to Intelligent Resource Sharing in Multiagent Systems: Extending the Contract Net Framework. In Proceedings of the First International Conference on Multi-Agent Systems, 457. AAAI Press / MIT Press

Schoonderwoerd, R., and Holland, O.; 1997. Ant-Like Agents for Load Balancing in Telecommunications. Networks In Proceedings of the First International Conference on Autonomous Agent , 209 - 216. ACM Press

Odubiyi, J., Kocur, D., and Weinstein, S.; 1997. SAIRE - A Scalable Agent-Based Information Retrieval Engine. In Proceedings of the First International Conference on Autonomous Agent , 209 - 216. ACM Press

Ostman. C.; 1997. Synthetic Sentience as Entertainment.*Midnight Engineering* Vol 8 No 2 p68 - 77.

HOME | Institute for Global Futures | NanoSig | Synthetic Environments | NanoBiology
GALLERY - Fine Art | Aesthetics of the Virtual Terraform | Mission Statement - A world in Transition | NanoTechnology - online book sample | Additional Info email Charles Ostman.