

Hierarchical Generalized Net Model of Behaviour Dilyana Budakova¹, Lyudmil Dakovski²

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Abstract

The article reviews a hierarchy of generalized nets, which represents sufficiently in details the processes in the world modeled by us and the related to the mental process of the intelligent agents populating it. The model set out in such a way enables to observe simultaneously in each position the behavior of the agents, the mutual relationship between an agent and an environment and among the agents themselves. In wider depth of the hierarchy it can be seen the change in the condition of the agents, the evaluation and analysis of the events in every moment, the alteration in the rules for action, switching over the context, etc.

Key words: *generalized nets, modeling, emotional intelligent agents, virtual environment*

Introduction

The behaviour of the agent is not determined solely by its internal system of conduct but also by the interaction with the environment [Ziemke 1997, 2000, 2001, Rylatt et al.1998].

Architectures of intelligent systems [Sloman 1997] and a number of computer models for expression and recognition of emotions are proposed. Many of the models include a virtual environment and agents that inhabit it. [Wright&Sloman 1996, Ruebenstrunk 1998, Sonnemans & Frijda (1994)]. In a number of models the training of the intelligent systems and their adaptation is embedded [Watkins&Dayan 1992, Holland 1995, Velasquez 1997, Gadanho&Hallam 1998, Botelho&Coelho 1998, Canamero 1997]. Recently, in a number of models senses and emotions are used as motivators and tools of education. [Franklin&McCauley 2004, Marsella&Gratch 2002, Bartneck 2003]. Lately, the approach of Bates [Bates et. al. 1992] has been adopted for modeling wide justifiable agents with a lot of capabilities, each of them being restricted to the necessity for the model. The aim is to understand and model the general principles laid down in the basis of the intelligent behaviour and cognitive capacity, as well as to realize and implement into application intelligent agents with a rational behaviour.

The proposed hierarchical generalized net model shows possibilities of generalized nets [Atanassov 1997] in that direction and here is described in details to the necessary level of complexity, which according to us enables every psychologist to design intelligent agents, to review the mutual relationships between them and the influence of events from the world. Individualities are modeled by assigning their characteristics, the rules for construction of decision making algorithm and for alteration of conditions, and after that the model is being gambled away as following the history of events, the behaviour of each token, the change in the condition of the agents, the alteration in the rules for choice of a reaction and development of the environment. Tokens – individualities and the medium are evolving mutually and influencing each other.

Some of the suggested generalized nets in the hierarchical generalized net model are realized and experimental results obtained.

Modeling virtual world

In [Budakova et al.2004b] it is put forward a generalized net model of virtual world with transitions corresponding to the basic human necessities and positions, which offer places to satisfy them /restaurant, firm, university, cinema, theater, hospital, bureau of labour, hobby, party, etc./. Each token in this net is individuality with characteristics: hierarchy of basic necessities, emotions in relation to these demands, thresholds of reaction, steps of changing the emotions, knowledge about the events and places worldwide.

In the proposed hierarchical model of this net here, each position is considered as a separate generalized net and each token – individuality also is reviewed as a generalized net. In fig. 1 this is pointed out by enlarging glasses. The depth of the hierarchy of nets for different positions and tokens vary. Different authors have been developing models of the processes in the virtual worlds, that can be used here as well. For example, in [Elliott 1992] is describing “taxi-world” and scripts with taxi drivers in Chicago. Description of this world by a generalized net can realize position “Moving forward by a taxi” from the generalized net illustrated in fig. 1. In the same way, there can be developed models for each position from the generalized net model in fig. 1

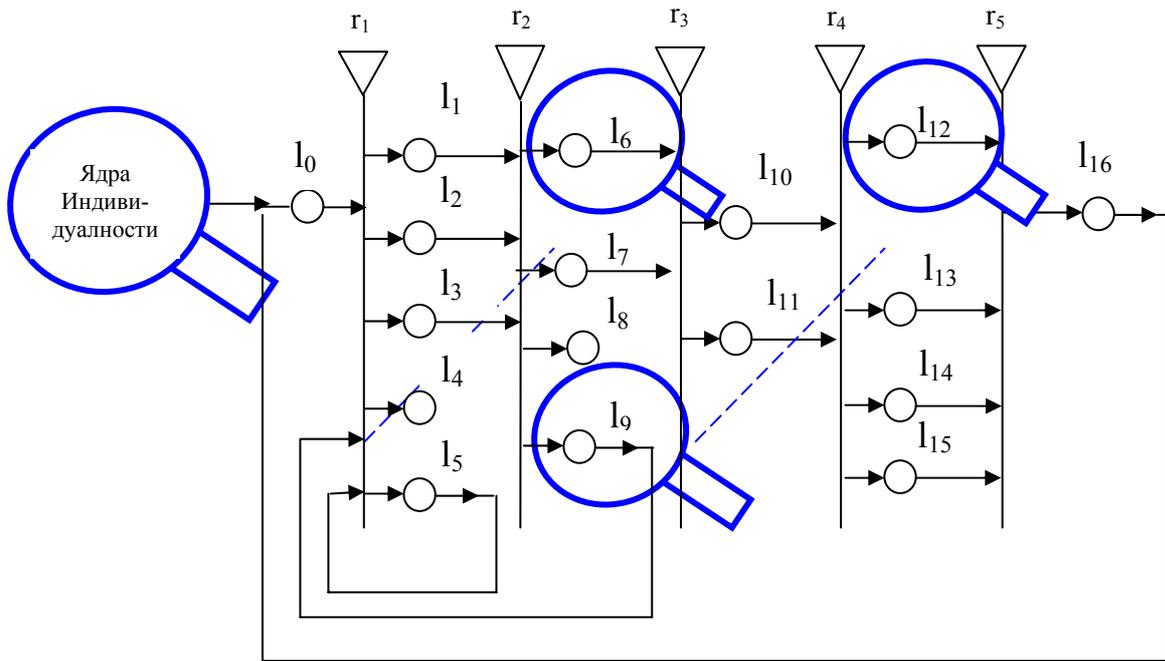


Fig. 1 Generalized net model of behaviour

Modelling Individualities

Each token in the net - generalized net model of behaviour (GN model of behaviour), can be represented with generalized net model of a mental process in a computer environment [Budakova et al.2003] fig. 2, since every token – individuality in this net realizes a mental process.

The transitions of the generalized net state the stages of the mental process, through which the external tokens – stimuli of the environment are transformed into a thought or a reaction. The mental process in the generalized net is described as a sequence of the following stages:

registration, recognition and transformation into a thought of a registered event (r1), consciousness about the event (r2) via a prompt, profound or comprehensive analysis, obtaining an emotional evaluation and probable change in the emotional status of the system (r3), decision making (r4) with possibilities to prolong the observation and the analysis or for moving forward towards the transition choice of a reaction and choice and implementation of a reaction (r5).

The internal tokens in the net are modeling the emotional condition of the individual and the knowledge about the analysis of the stimuli. In concrete terms, the description of the internal tokens is the following:

They are composite internal tokens, which are being created, changed and used from transitions (r2) and (r3), while from transition (r4) they are only used. They are tokens for the condition and priorities of the modeled personality, tokens for the rules of choice for action and tokens for reflection of the impact of an event on the personality and its emotional status. Each of these composite internal tokens consist of elementary tokens, which present prerequisites of one rule or aspects of one condition, emotion or impact in relation to a given necessity. In fig. 2 they are illustrated with the feedbacks in transitions (r2), (r3) и (r4).

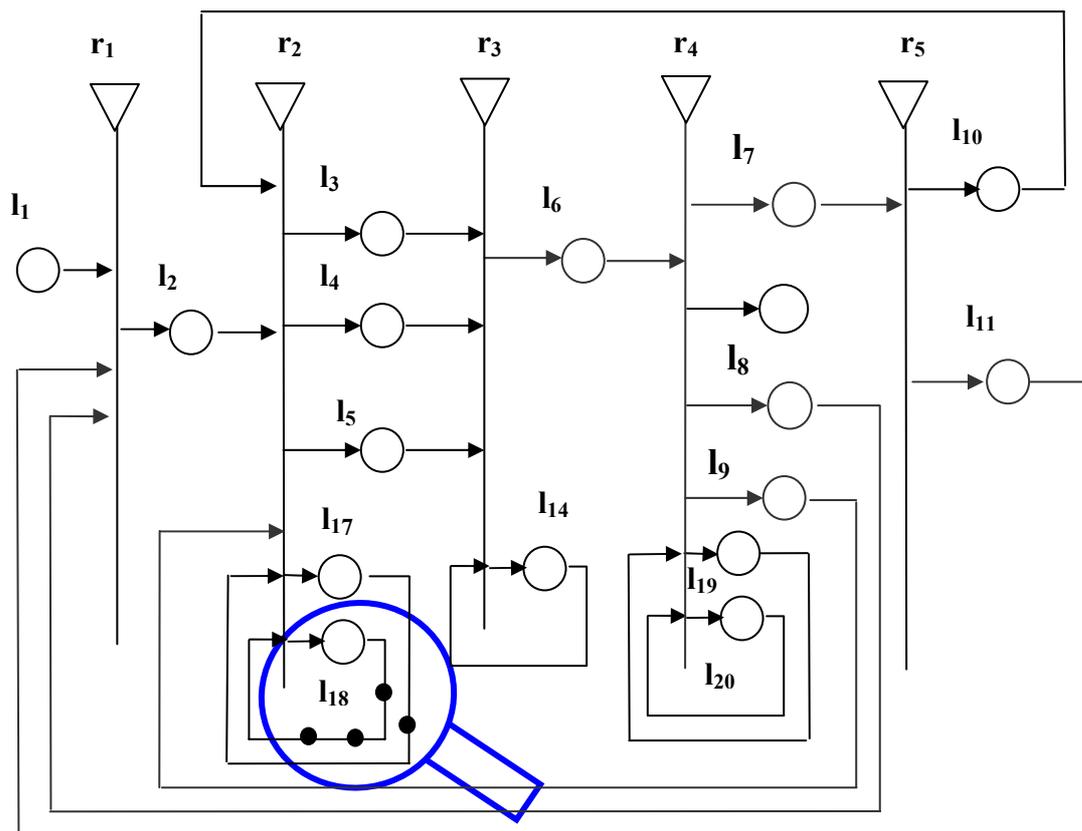


Fig. 2 Generalized net model of a mental process in a computer environment, which presents tokens – individualities, inhabiting the virtual world modeled by us.

Now, internal tokens are being added, which represent rules for construction and change of behaviour rules of the intelligent agents, i.e. meta-rules. They define the “consciousness” of the agent.

Transition (r4) decides whether to continue with the analysis of the same context, whether to get forward to analyzing another subject, whether to prolong the observation of a given event or be rejected, how often to switch over between different contexts, whether to pass on to a choice of reaction. The frequency of change of the analyzing subject determines the degree of “absent-mindedness” of the agent.

Internal tokens of transition r(4) are simultaneously global internal tokens for the generalized nets, which realize positions (l10 or l11) of the transition choice and implementation of a reaction (r5).

Positions of the transition choice and realization of a reaction (r5) select between activation of: generalized net model for realization of a creative process given in [Budakova et al.2003b]; generalized net model for implementation of the process of gathering data with a view of forming a behaviour realized in [Budakova et al.2003]; or select a performance of another action. After that, it is preceded to transition (r1) or (r2) as it is shown in fig.2.

In [Budakova et al.2003b] it is put forward a generalized net of a program system for collection of data aiming at formation of behaviour fig. 3. The first transition allows that the agent gather opinions and information in a relevant format for self-interpretation, and the second transition enables for the agent to express a thought maximum closer to the view point, emotional evaluation and the level of understanding of the interlocutor. Then, it is moved on again to the transitions of generalized net model of a mental process and a decision is taken how to proceed.

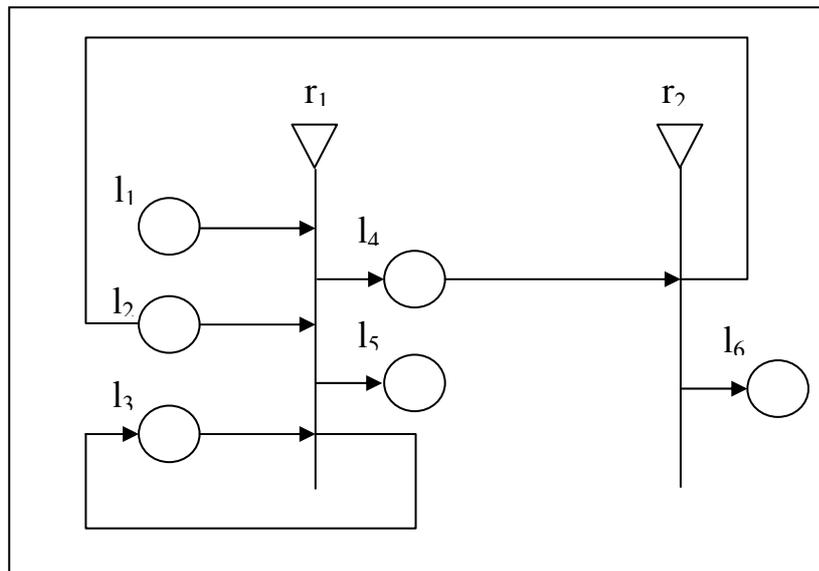


Fig. 3 Generalized net model for gathering information and its extraction with the purpose of forming a behaviour

When the selected reaction of the system is the transition into a creative condition, then a generalized net model for carrying out of a creative process(fig.4) is being activated [Budakova et al.2004].

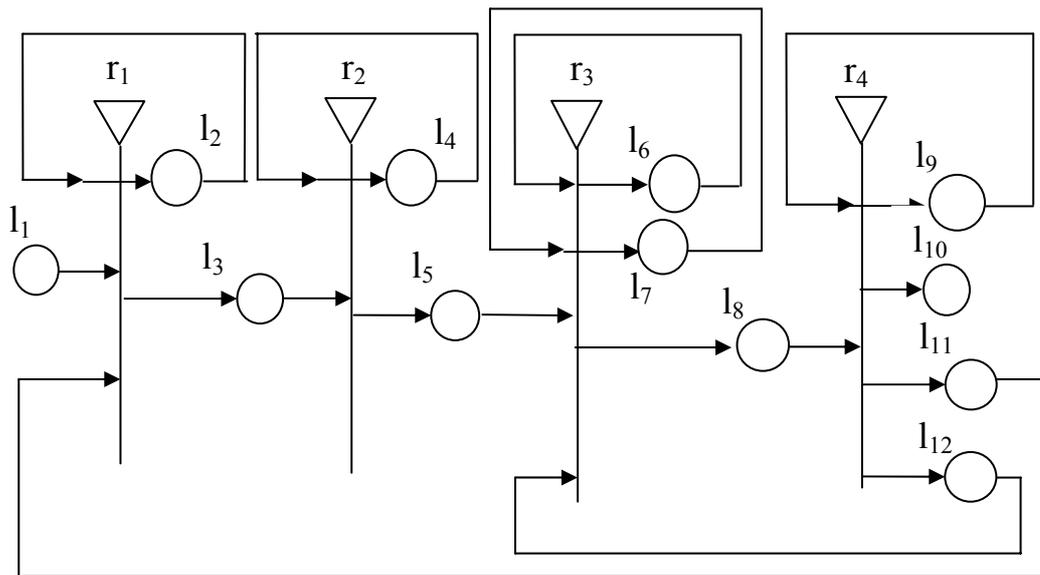


Fig. 4 Generalized net model for compiling verses. It is controlled by the global external tokens and the essays concurrently influence the condition of the intelligent agents.

Intelligent agents, as well as people can move to a creative condition at work, at home, when dealing with their occupations, when within nature, etc. The set out generalized net in is a model for compiling verses, in which if there are not requirements for rhyming and step of the verses, there will be obtained completed expressions following a given thematic.

Local external tokens for this net are the initial words and phrases that passing through the net are transformed into expressions, out of which there have been selected the most appropriate ones for receiving the final verses, letters and other essays. The change of the global external tokens (condition of the agents) leads to alteration both of the verses being compiled, and to a change in the selection of the initial words and expressions, etc. In addition, vice versa, the essays themselves reflect on the condition of the intelligent agent, writing them.

For example, in a bad mood towards the negative aspects of the words and expressions, a constant value is being proportionally added, and in a good mood, such a value is supplemented towards the positive aspects of the expressions. The preferred words are being changed.

Strategies of the random choice of tokens in the realization of a creative process

For construction of essays under a given thematic, the following strategies for choice of tokens (words and expressions) apply:

A. The first word is taken, that corresponds to a certain degree to the senses of the agents.

B. A maximum is being searched for, i.e. the most appropriate word or expression, that best complies with the given sense in the input. In this strategy, however there should be awaited for all words to pass through in order to find the most suitable one.

C. Another strategy is linked to the row, along which it will be going around the memory seeking for a word or an expression that fits best:

1. words and expressions circulate in sequence
2. words and expressions are indexed and a random choice can be arranged

3. the order of words and expressions in the memory is determined by indices of 1 to n and the access to them can be:

- a) arbitrary
- b) according to utilization

4. words and expressions can be grouped:

- a) by emotions – then, only words and expression with this emotions can circulate
- b) grouped by emotions and indexed by utilization
- c) grouped by emotions and arranged by increasing or decreasing order of emotions

Depending on the mood and subject, it is dealt with relevant types of sentences. For example, in a high mood, more exclamation sentences are being used.

Description of the tokens forming one personality and processes of its training

First stage. For every virtual intelligent agent an identity is being created as three kinds of internal tokens are assigned:

- characteristics of the agents – facts associated with each necessity, senses on the occasion of the facts, values – weight of the data, thresholds /physiological and psychological one, threshold of the mood and threshold of the emotions/, step of change of the values of each aspect of a fact in a positive direction, turn for a change of each aspect of a fact in a negative trend, in every moment. Minimum and maximum value of the data is assigned and it is observed that these limits be not exceeded.

Internal token 1. Condition of the modeled personality

Name/gender/age/=agent

Fact/Necessity/Sense or another characteristic/Step/Time/Threshold_mood/

Threshold_Physical1/Threshold_sense/Threshold_Psycological2/.../Step+/
Step-/Value/Agent

- rules for a choice of action or position by the agent. All prerequisites are determined.

Internal token 2. Rules for choice of an action or a place

Agent/Action or Place/If a fact exists/If Necessity/If Emotion or Characteristic/If value>Threshold 1/If value>Threshold 2...

- rules for determination of the consequences of one action, event or an observation on the condition of the agent. It is defined under what conditions exactly, which characteristics are being changed and in what way.

Internal token 3. Rules for impact of events, observations and reactions on the modeled intelligent agent.

Agent/Action or Place/Emotion or Characteristics/Change Threshold 1/

Change Threshold 2/Change Step+/Change Step-/Change Value/Fact/Necessity

- rules or functions for change of rules for a choice of action or for establishing the consequences of one event upon the agent.

Second stage

This is the lifetime of the agent in the virtual environment. It is in conformity with the time for training of the agent. During this stage, the modeled agents are being changed by the events in the environment and by the choices made. The trend in the course of training is striving to meet their necessities according to the theory of Maslow [Maslow 1970] for a healthy personality.

- New fact arises in relation to a given necessity

- New aspects of the facts rise up

- Existing aspects of the facts, their values or the values of steps in a positive or negative direction are changing

- New emotions with reference to given necessities come up or values of the existing ones alter

- The values of thresholds change /physiological and psychological ones/ of a reaction with regard to the facts related to a given necessity
- The values of the limits (minimum and maximum ones) of alteration of the facts change
- New preconditions for a choice of action emerge
- New prerequisites for reflection of one event on the agent occur
- The impact of a given action or an aspect of observation also changes
- Facts are being removed, aspects and facts are moved away
- Prerequisites from the rules for a choice of action or preconditions from the rules for influence of an action/observation on the agent are cancelled
- Aspects of impact of the actions on the agent are eliminated
- One event usually influences the agent in a complex way, and not only a particular emotion, for example

Lower threshold of a reaction of one prerequisite means larger importance of the precondition.

Cognitive and non-cognitive prerequisites are taken into consideration. The rules for a choice and the rules for impact of an event on the agent are in compliance with the current situation of the agents. Under different conditions there are possible or impossible various actions, behaviour, decisions and assessments. For example, a conduct through masking/simulation is possible only in definite borders. The rules for a choice and reflection of the environment differ in the healthy person and in mentally diseased one. A number of connections are missing in psychopaths – preconditions to a choice of action or influence of environment.

Besides the proposed two thresholds – physiological and psychological one, there are other thresholds according to [Velasquez 1997]. Such ones, for example are the thresholds for coming up with a mood and a threshold for passing it into a sense. It is possible that the values of the physiological and psychological threshold be altered in size one towards another, while the thresholds for emerging a mood and a sense are precisely arranged.

The mood is more continuous and first arises at lower values and attenuates slower than the feeling.

The steps of changes for every aspect of a fact are different both for the various facts and for the two directions of increase and decrease. The thresholds can also change upwards and downwards. This is a very flexible and available mechanism for training.

Step. Each step in the net comprises minimum of two sub-steps. The first one is for establishing a token – agent in a given position, and the second one is for setting up which are the other agents and events, that come about in this place. The condition of the agent can be changed in the second or the next sub-step.

If for making one decision there are prerequisites, taking into account aspects of the opinion or a reaction of another agent living in the environment, then there exists training between the agents themselves.

How the choice of a rule for action takes place? It is not selected the rule, that pertains to the highest value of the weight, as it is in the trivial occasion. Now upon choice, a prerequisite should have a maximum value, and another one – a small value, third precondition should not exist, and the fourth must have some small value or a value over one of the thresholds, etc.

Since there is a dependence on the mutual reactions and values of the agents, a sequence of wrong decisions, reactions and states can be obtained, which at first glance seems to be grounded, but at the end lead to disappointment. Such is the situation in our society. It is not known beforehand which is the correct rule for a choice, the exact reaction or change of the state. Finally, it is reached to the right decisions.

Conclusion

Hierarchical and generalized net model of behaviour is put forward. It consists of a hierarchy of nets, which present a virtual world and tokens – emotional intelligent agents inhabiting it. Each token – intelligent agent in this model is represented by a net, which realizes a mental process and can activate other nets for implementation of a chosen behaviour. Every agent is able to analyze the events from the world, to alter his emotional status and assessments, can select his conduct and change the rules for behaviour. These possibilities are called training of an intelligent agent. The aim is to cover the basic necessities of the agents, which are physiological ones, security, love and pertinence, evaluation and self-evaluation, self-actualization and aesthetic demands. Agents interact in training and evolve the world in which they are living. The events from the virtual world also influence them.

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