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P.S. SAPATY*

SPATIAL MANAGEMENT OF MULTIDIMENSIONAL INTERNATIONAL WORLD

*Institute of Mathematical Machines and Systems Problems of the National Academy of Sciences of Ukraine, Kyiv, Ukraine

Анотація. Поняття «багатовимірний інтернаціональний світ» стосується розуміння світу через його численні виміри, що виходять за рамки традиційних економічних чи політичних міркувань, шляхом сприяння міжкультурній співпраці та балансуванню глобальної інтеграції з місцевими потребами. Спочатку у статті аналізується багатовимірною природою людського суспільства, включаючи міжнародні відносини, та розглядаються публікації з різних світових вимірів, як-от політичний, економічний, безпековий, правовий, культурний, соціальний та технологічний. У ній коротко описуються розроблена високорівнева Модель та технологія просторового захоплення (ТПЗ), яка може досліджувати та керувати складними системами за допомогою цілісного просторового підходу, ефективно охоплюючи різні фізичні і віртуальні виміри та їх інтеграцію. У статті описуються основи багатовимірної системи управління, яка наразі розробляється, та наводяться приклади практичних рішень у різних вимірах та їх комбінаціях Мовою просторового захоплення (МПЗ), ключовим елементом ТПЗ і з мережевими представленнями рішень. До них належать міжвимірний вплив та оптимізація, пошук багатовимірних спільнот, демонстрація багатовимірного відновлення після катастроф, пошук небезпечних багатовимірних угруповань, ізольованих багатовимірних компонентів, а також взаємодія фізичних та віртуальних вимірів. Використовуючи хвилеподібну просторову якість МПЗ, результати операцій, отримані в одних вимірах, які потім передаються в інші виміри, або ж весь процес нероздільно поширюється між вимірами в цілому. Різні версії ТПЗ були протестовані на численних застосуваннях, і його остання версія, особливо придатна для багатовимірного управління, може бути швидко впроваджена на будь-яких існуючих платформах та інтегрована з передовими системами зв'язку.

Ключові слова: багатовимірний світ, Технологія просторового захоплення, Мова просторового захоплення, розподілені мережеві операції, дослідження та управління вимірами, колективні багатовимірні рішення, глобальна цілісність.

Abstract. The concept of «multidimensional international world» refers to understanding the world through its multiple dimensions beyond traditional economic or political measures, by fostering cross-cultural collaboration and balancing global integration with local needs. The paper first analyzes the multidimensional quality of human society, including international relations, and reviews publications on different world dimensions like political, economic, security, legal, cultural, social, and technological. It briefs the developed high-level Spatial Grasp Model and Technology (SGT) which can investigate and manage complex systems with a holistic spatial approach effectively covering different physical and virtual dimensions and their integration. The paper describes the basics of a multidimensional management system that is currently under development and provides examples of practical solutions in different dimensions and their combinations in Spatial Grasp Language (SGL), the key element of SGT, with networking representations of the solutions. These include interdimensional influence and optimization, finding multidimensional communities, showing multidimensional recovery after disasters, finding dangerous multidimensional groupings, isolated multidimensional components, as well as interaction of physical and virtual dimensions. Using the wavelike spatial quality of SGL, the results of multidimensional operations obtained in one dimension are then explicitly delivered to other dimensions, or the whole process is inseparably propagating between dimensions as a whole. Different versions of SGT have been tested on numer-

ous applications, and its latest version, especially suitable for multidimensional management, can be quickly implemented on any existing platform and integrated with advanced communication systems.

Keywords: multidimensional world, Spatial Grasp Technology, Spatial Grasp Language, distributed network operations, dimension investigation and management, collective multidimensional solutions, global integrity.

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1. Introduction

The word «multidimensional» in relation to human societies may have different expressions and meanings, including the following. Multidimensional society is one that recognizes and analyzes complex issues through multiple perspectives rather than a single-factor view [1]. Multidimensional international relations recognize that global interactions involve diverse facets beyond politics and war, encompassing economic, cultural, technological, legal, social, and environmental dimensions [2]. Multidimensional diplomacy means that states often negotiate with each other over more than one issue at the same time, and can send signals about their resolve that have dramatic effects on other states' beliefs and actions [3]. Managing international multidimensional worlds involves navigating complex factors that impact multinational corporations, virtual teams, and global supply chains [4].

We have studied and analyzed in detail many existing publications on different world dimensions, including the following: political [5–8], economic [9–12], security [13–16], legal [17–20], cultural and social [21–23], technological dimensions [24–27], etc.

The *aim of this paper* is to review and explain how the distributed international world is organized as a set of interacting dimensions and investigate the potential and practical applicability of the developed Spatial Grasp Model and Technology (SGT) for effective management of large and complex multidimensional systems.

The rest of the article reviews the basics of SGT and its distributed implementation (Section 2), describes the basics of a multidimensional management system which is currently under development (Section 3), provides an example of inter-dimensional influence and optimization (Section 4), describes finding multidimensional communities (Section 5), shows multidimensional recovery after a disaster (Section 6), hints how to find dangerous multidimensional viral or mental groupings (Section 7), discovers isolated multidimensional nodes and groups (Section 8), and describes the interaction of physical and virtual dimensions (Section 9). Section 10 concludes the paper, with References citing the used publications.

2. Spatial Grasp Model and Technology Summary

SGT [28–43], a high-level operational scenario expressed in a recursive Spatial Grasp Language (SGL), starting in any world point or points, propagates, covers, and matches the distributed environment in a parallel wavelike mode, as symbolically shown in Fig. 1. Such propagation can result in returning and analyzing the reached states and data, which may be arbitrarily remote, or be used for launching more waves, also jointly in both cases.

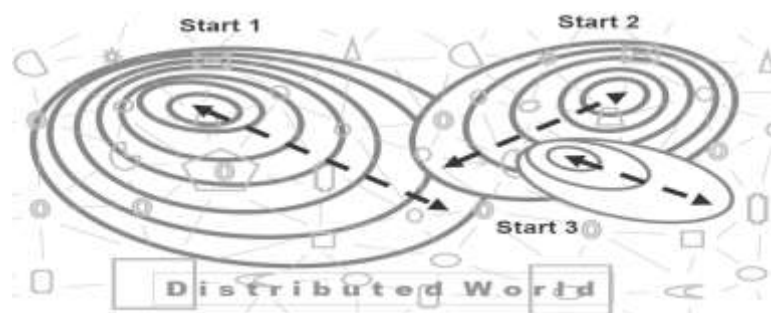


Figure 1 — Parallel recursive world coverage with Spatial Grasp Model

The distributed worlds this model effectively covers, conquers, and manages may be of different types: *Physical World (PW)*, *Virtual World (VW)* and *Executive World (EW)*. Different combinations of these worlds can also be possible within the same formalism.

SGL as a basic concept of SGT, allows for direct space presence and operations with unlimited powers and parallelism. Its top level universal recursive organization, with operational scenarios called *grasps*, can be expressed as follows:

grasp → *constant* | *variable* | *rule* ({ *grasp*, })
constant → *information* | *matter* | *custom* | *special*
variable → *global* | *heritable* | *frontal* | *nodal* | *environmental*
rule → *type* | *usage* | *movement* | *creation* | *echoing* |
verification | *assignment* | *advancement* | *branching* |
transference | *exchange* | *timing* | *qualifying*

The SGL rules, starting at certain points, can organize navigation of the world sequentially, in parallel, or in any combination thereof. They can result in the same application points or cause movement to other points with obtained results left there or returned. The final points can become starting ones for other rules. The rules, due to recursive language organization, can form arbitrary operational infrastructures expressing sequential, parallel, hierarchical, up to fully decentralized, and distributed algorithms.

Communicating SGL interpreters can be in an arbitrary number of copies effectively integrated with other existing systems and communications, representing altogether powerful spatial engines operating without central resources or control.

3. Multidimensional management system

The general view of this project organization is depicted in Fig. 2, which consists of overlaying and communicating spatial dimensions, and a Global Management (GM) system allowing for entering, analyzing, and optimizing different dimensions and their interactions as the unified whole.

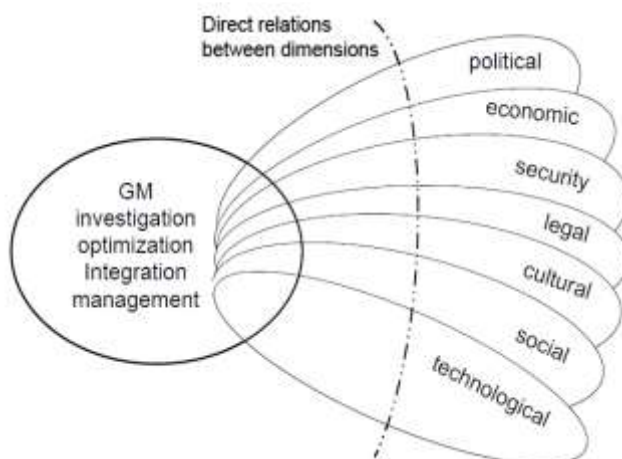


Figure 2 — Multidimensional management system

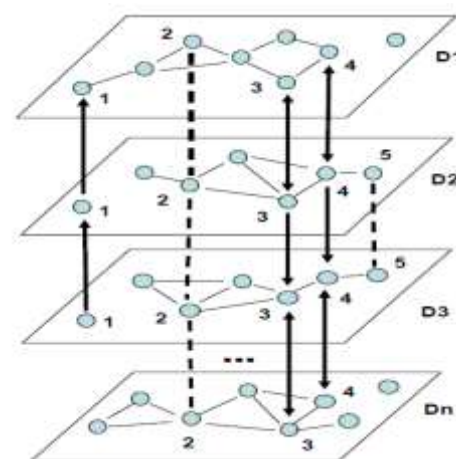


Figure 3 — Interactions between dimensions

Fig. 3 shows some ideas of how different dimensions can be organized and interconnected, with direct contacts of versions of the same nodes in different dimensions. The directed arrows between node versions reflect the superiority or equivalence of the same named nodes in multidimensional integrity. Dashed non-oriented links show that all versions are equivalent throughout the multidimensional system. In each dimension, different nodes may form arbitrarily complex networks reflecting their type, ideology, and operation, which may depend on interac-

tions with nodes in other dimensions, especially the same named ones. Types of relations between nodes in different dimensions may be unique for these dimensions.

The following examples show how to enter different dimensions, solve problems in them, and how to move between dimensions. Entering any dimensions from GM by operation `enter`, reaching certain points there, and organizing operations from them may look as follows:

```
enter(Political, Economic, ...); hop(name_1, ..., name_n); <operate>
```

Also, when staying in a node in any dimension, you can directly slide into the same named node (or nodes) in other dimensions (if such exist) and continue to operate there, thus avoiding the use of GM by special operation `shift`, like

```
<staying in a node>; shift(Economic, Technological, ...); <operate>
```

4. Example of interdimensional influence and optimization

In this section, we will study how the findings in one dimension can influence a solution in other dimensions, considering for this a possible interplay of political and economic dimensions symbolically shown in Fig. 4.

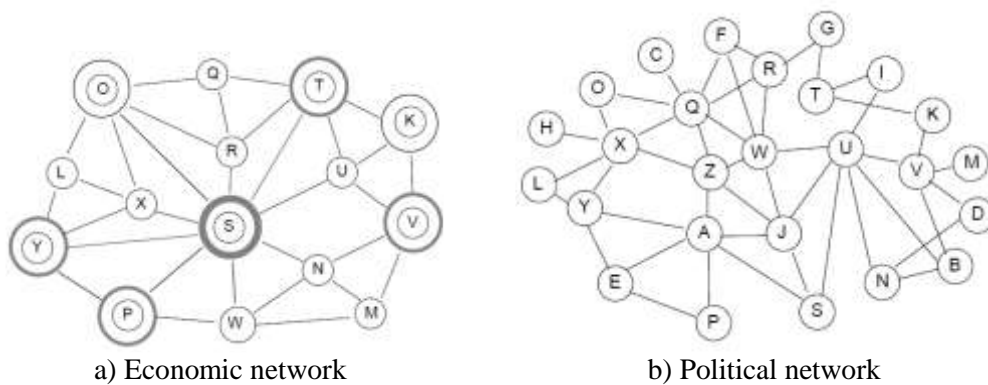


Figure 4 — Economic and political network examples

Let us first find countries with the most powerful economies using the network example from Fig. 4a, which symbolically reflects the economic power of different countries by the size of the respective nodes, taking into account that the countries of interest should have personal economic POWER exceeding some threshold. Initially staying in GM, entering the economic dimension with the registered countries-nodes in it, and then returning to GM the needed node names in the variable `Nodes`, it may look as follows:

```
Nodes = (enter(Economic); hop(nodes); POWER > threshold; NAME)
```

Having received the list of names of powerful economic nodes like S, T, V, Y, and P (Fig. 4a), now we can try to add economic-political relations between all the same named nodes within the political dimension network (Fig. 4b), with the result (in dotted links) shown in Fig. 5. Such new links may be useful for developing both economic and political cooperation between these countries, thus benefitting global development and prosperity.

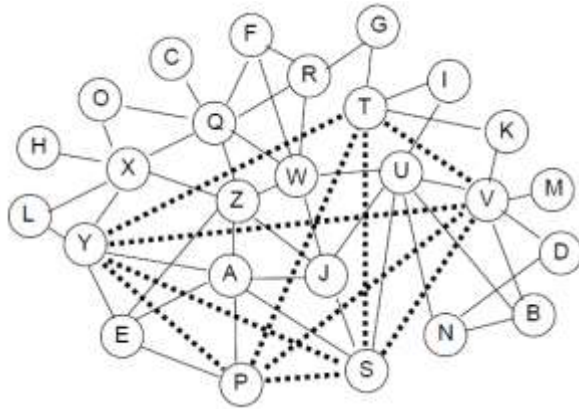


Figure 5 — Adding new relations in the political network

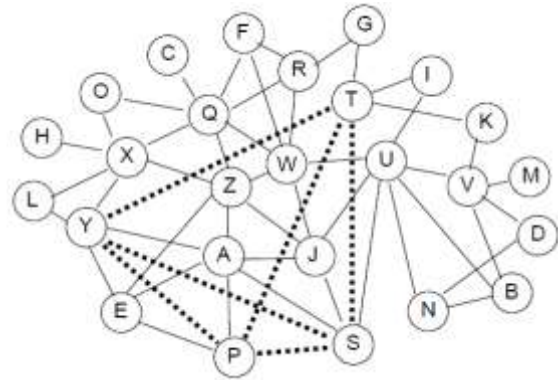


Figure 6 — Solution 2

The full solution involving the sequence of operations in both dimensions will be as follows, with `ecopol` as the name of new economic-political relations in the political network:

```
frontal(Nodes) = (enter(economic);
                  hop(all_nodes); POWER >= threshold; NAME);
eneter(political); hop(Nodes); split(Nodes);
if(NAME > VALUE, linkup(ecopol, node(VALUE)))
```

Modification of this decision may be to interlink nodes only if they are all directly interconnected in the economic network, thus excluding from consideration node V not having direct links with S, T, Y, and P as in Fig. 4a. The updated and interlinked set of nodes can be received by the following updated procedure. The obtained solution, or Solution 2, will be as shown in Fig. 6.

```
enter(economic);
frontal(Nodes) = (hop(all_nodes); POWER >= threshold; NAME);
Nodes = (hop(Nodes); if(hop(link, Nodes), NAME));
enter(political); hop(Nodes); split(Nodes);
if(NAME > VALUE, linkup(ecopol, node(VALUE)))
```

More dimensions may need to be considered for this solution, rather than just two, including others like cultural, legal, security, technological, defense dimensions, etc. Otherwise, it may happen not so useful for the global system and can potentially cause problems or even conflicts. Further modification of Solution 2 may be reached by additionally considering the defense dimension, which can contain different and potentially conflicting security blocks B_i as in Fig. 7. In this respect, the solution may be further modified by interconnecting only nodes from the same security block or from no blocks at all. So, the next solution, Solution 3, can only include nodes T and Y of B_1 and node S not registered in any blocks as shown in Fig. 8. Its expression in SGL may be as follows:

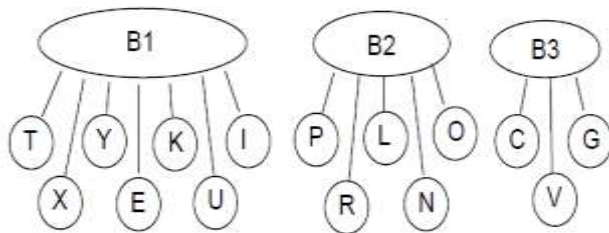


Figure 7 — Military-security blocks

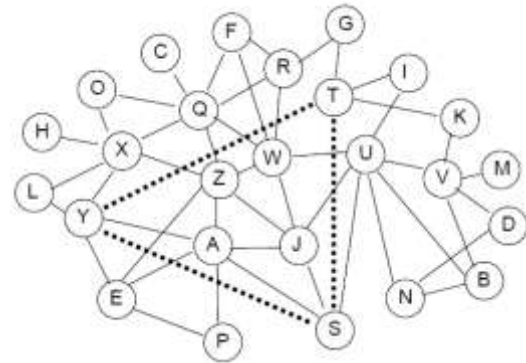


Figure 8 — Solution 3

```

enter(economic);
frontal(Nodes) = (hop(all_nodes); POWER >= threshold; NAME);
Nodes = (hop(Nodes); if(hop(link, Nodes), NAME));
enter(security);
Nodes1 = sequence(hop(B1, B2, B3); and(hop(link, Nodes); NAME),
stop));
Nodes = Nodes1 & (hop(withdraw(Nodes1, Nodes)); nolinks; NAME);
enter(political); hop(Nodes); split(Nodes);
if(NAME > VALUE, linkup(ecopol, node(VALUE)))

```

5. Finding multidimensional communities

Finding different communities in a multidimensional world is considered a very important and complex task [44–46], with a related example following. In Fig. 9, the initial community of interest is shown in dimension D1, which includes only nodes interconnected by special links named *commun*. After that, we should find interconnected nodes with the same name in another dimension, and so on, finally obtaining nodes that are interconnected in all considered dimensions. These will be nodes 2, 3, 4, and 6 in the final dimension D3, actually representing the resultant multidimensional community. The SGL solution for this stepwise spatial process may be as follows:

```

enter(D1); frontal(Nodes) = (hop(all); if(link(commun), NAME));
enter(D2); Nodes = (hop(Nodes); if((link, Nodes), NAME));
enter(D3); output(hop(Nodes); if((link, Nodes), NAME))

```

Another solution with a direct propagation between the nodes in different dimensions may be as follows (also shown in Fig. 10), where only Start and Fin stages are explicitly represented, without Mid ones as in Fig. 9. The resultant node names will be output individually by the final nodes themselves, i.e. in the last dimension.

```

wait(wait(...
  enter(D1); hop(all); if(link(commun), (shift(D2); mark)));
  if((link, marked), (shift(D3); mark)));
  .....
  output(if(link, marked), NAME))

```

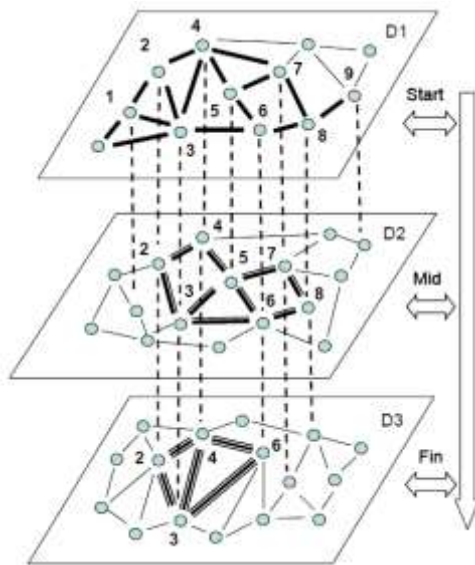


Figure 9 — Obtaining a resultant community

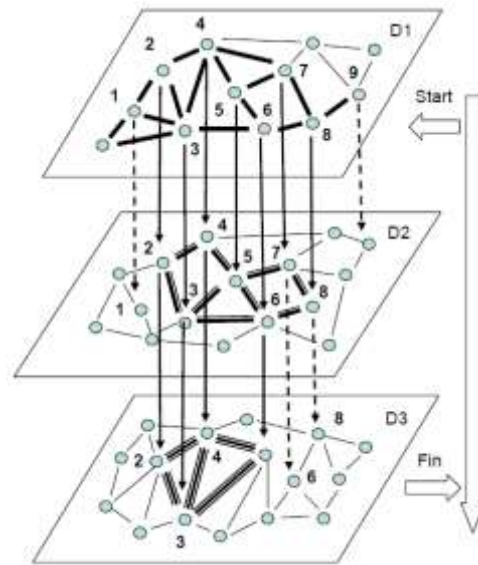


Figure 10 — Using a direct interdimensional propagation

6. Recovering after a disaster

Let us imagine that an earthquake, explosion, or any extreme weather condition (with the given center and radius R_1) covered the geography dimension region surrounded by the dashed border-line in Fig. 11, which includes nodes W and J . The recovery process may simultaneously involve different dimensions. Concerning the communication and transport dimension, this should first outline and prepare the nearest transport network surrounding the damaged area (dashed line with radius R_2), with road capabilities to be converted to *recovery* ones. Then, from nodes of this network, we may inform the nearest security, construction and economic agencies (dotted links in Fig. 12), which can be potentially involved in the recovery and rebuilding process, already having the prepared *recovery* routes for their operations (hard links in Fig. 12). The following SGL multidimensional solution can organize this as follows.

```
frontal(Center = ..., R1 = ..., R2 = ..., Damaged, Around);
Damaged = (enter(Geography); hop(Center); cover(distance(R1)));
Around = (enter(Geography); hop(Center); cover(distance(R2));
          notbelong(Damaged));
sequence(
  (enter(Transport); hop(Around); hop(link(transp), Around);
    if(NAME > BACK, linkup(recovery, BACK))),
  (enter(Security, Construction, Economy);
    hop(Around; hop(links(sec, econ, tech), not(Damaged));
    operate(Damaged)))
```

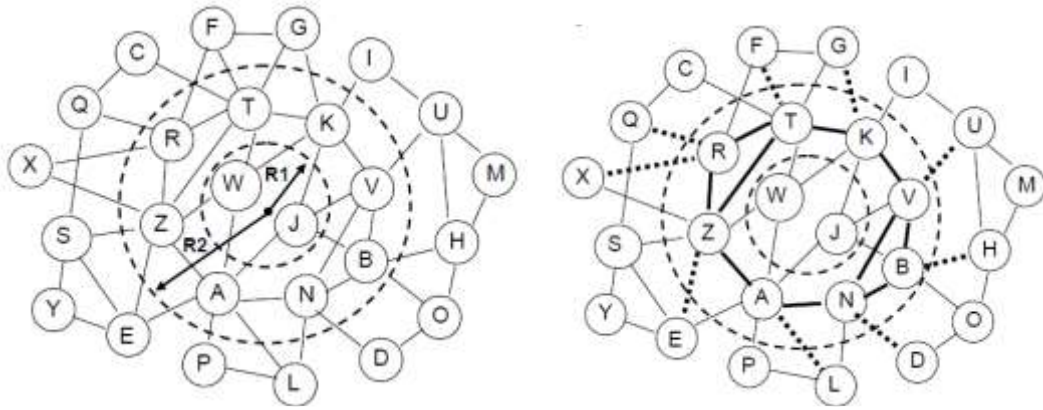


Figure 11 — Disaster in a geography dimension Figure 12 — Surrounding roads and recovery dimensions

7. Finding close ideological, viral, or mental communities

It is supposed that if somebody possesses a sort of hidden and dangerous mental or viral feature, a human community that is very close with this person (say, organized as a clique, with everybody actively communicating with each other) may be hypothetically considered as having this quality too. Let us imagine that we implant this viral feature into some human clique (1, 2, 3, 4, 5) at dimension D1 of Fig. 13 via its node 3. Then, if any member of this clique has the same node, like 4, in another dimension D2 and happens to be a member of some other clique in this dimension, we may assume that the whole new clique may potentially be infected via this node too, like clique (4, 6, 7, 8). Extending this process to dimension D3, which has versions of infected nodes 7 and 8 from D2, we may assume that these nodes can also provide fully infected cliques like 8, 9, 10, and 11 and 7, 12, 13, and 14 in D3.

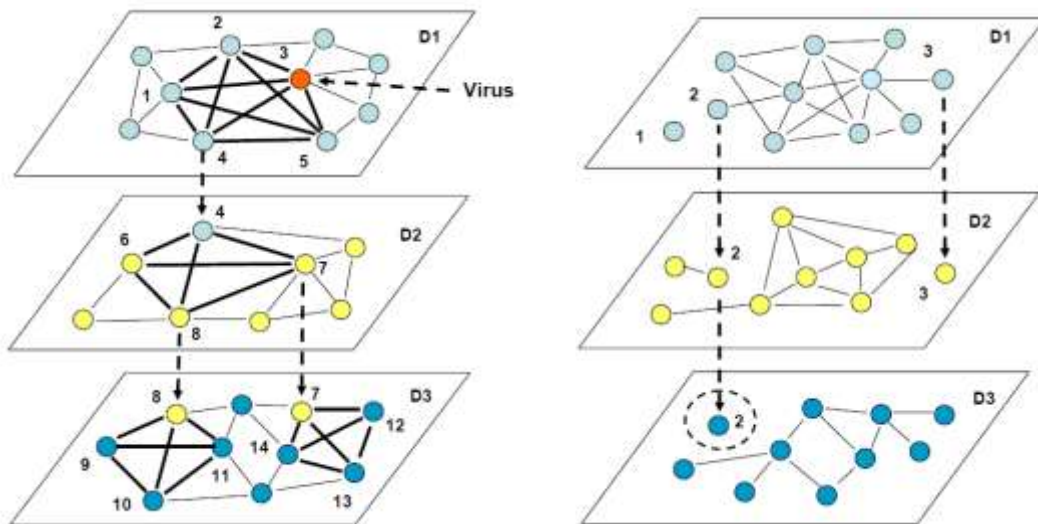


Figure 13 — Finding dangerously infected communities Figure 14 — Finding the most isolated nodes and groups

Only two steps of this spatial process are shown below in SGL, for D1 and D2, with more dimensions to be processed similarly, where cliques of interest are supposed to have at least 4 interconnected nodes. The output infected clique at D2 will be 4, 6, 7, and 8.

```
frontal(Clique) = 3;
```

```

Clique =
  (enter(D1); hop(Clique);
  repeat(
    hoplinks; notbelong(NAME, Clique);
    yes(andparallel(hop(links, Clique)));
    append(Clique, NAME));
    count(Clique) >= 4; Clique);
enter(D2); hop(Clique); Clique = NAME;
repeat(
  hoplinks; notbelong(NAME, Clique);
  yes(andparallel(hop(links, Clique)));
  if(PREDECESSOR > NAME, append(Clique, NAME), stop));
count(Clique) >= 4; output(Clique)

```

8. Finding the most isolated nodes and groups

To find the weakest and the most isolated parts in a multidimensional system, we will look for nodes with a minimum number of links to other nodes throughout different dimensions. The nodes present in all dimensions, like node 2 (in D1, D2, and D3) in Fig. 14, can be of most interest. Partial interest may also pose node 1 (only in D1) and node 3 (in D1 and D2). One of the goals for discovering and analyzing such nodes may be their further additional intensified development and strengthening, including linking with more nodes in different dimensions, thus strengthening the whole community too. Finding such nodes throughout all the dimensions from D1 to Dn in SGL may be as follows (with *threshold* representing the maximum number of links with other nodes which may still consider the node as weak or even isolated (especially with no links at all, as node 1)):

```

frontal(Dim) = (D1, D2, ..., Dn);
enter(withdraw(Dim)); hop(nodes);
repeat(
  if(count(links) < threshold,
    orseq(shift(withdraw(Dim)), end(output(Name))))

```

9. Interaction of physical and virtual dimensions

In a physical world dimension PW1 in Fig. 15, the physical structure with nodes 1, 2, 3, 4, 5, and 6 is found, analyzed, and its detailed copy provided with all needed features of these nodes (like types, widths, heights, material, physical coordinates, etc.) and their interconnections. All this data is then stored as a special knowledge in the virtual dimension KVV, which also accumulates similar information on many other structures, events, individuals, and organizations, which can be effectively operated and processed on a virtual level and also used in other dimensions, both virtual and physical. For example, using this stored physical data structure in KVV with detailed additional formatting information *Format* (like on new node coordinates and shapes), a physical copy (say, a reduced one) of the above-mentioned physical structure can be created and placed in another physical world dimension like PW2 in its proper place, say, for its extended investigation and improvement. The multistage solution for this task using different dimensions in SGL may be as follows:

```

enter(KVV);
frontal(Nodes) = (1, 2, 3, 4, 5, 6);
frontal(NodesP) = (enter(PW1); hop(Nodes); NAME & FEATURES);

```

```

frontal(Net) = (enter(PW1); hop(Nodes); NAME & (hop(links,
Nodes); NAME)
enter(PW2);
frontal(Format = ..., Linktype = ...);
sequence(
(split(NodesP); create(VALUE[1] & update(Format, VALUE[2]))),
(split(Net); hop(VALUE[1], linkup(Linktype, VALUE[2])))

```

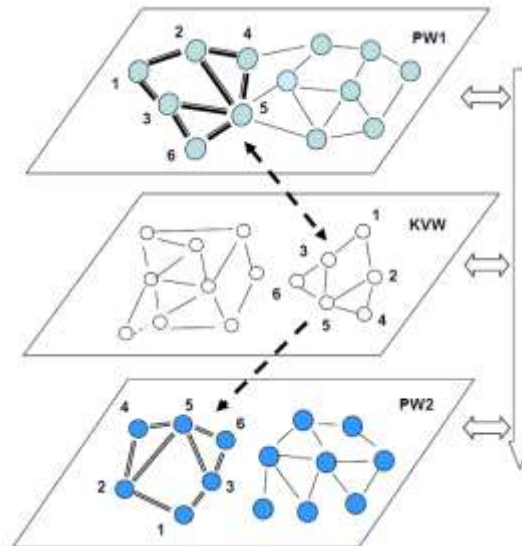


Figure 15 — Interaction of physical and virtual dimensions

10. Conclusions

The paper confirms the necessity and high importance of understanding the distributed international world through its multiple dimensions, which needs detailed investigation separately and collectively to guarantee the proper world development. It also proves the suitability and efficiency of the developed SGT–SGL paradigm for investigating, modifying, and improving different dimensions and their holistic integration and management, where effective operations and solutions for the networked dimensions can be organized in a parallel and fully distributed mode. These solutions in SGL may be simpler and much more compact than with other models and languages (by experience with solving complex tasks in other areas, as already mentioned in [29–39]). SGT is fundamentally based on quite different world vision and understanding in comparison with other models and languages, and the word «spatial» in its name fundamentally relates to the very human existence, evolution, and activity in large distributed spaces, including finding solutions related to crises and disasters, which may need covering large physical, virtual, and emotional dimensions [42, 43]. As a result of this paper, as well as of the previous one [40], this psychology, ideology, and paradigm can be effectively used for the global optimization and management of the whole international community, which is very complex, distributed, heterogeneous, and multidimensional. The latest SGL version can be effectively and quickly implemented in traditional environments and recommended to different local and global institutions, including the UN, for the support of stability and evolution of the international community.

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