Spatial Management of International Multidimensional Disputes

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Abstract

This paper relates to the new project, currently in development, which treats complex distributed systems, international especially, as consisting of overlaying spatial dimensions, while allowing us to analyze and optimize different dimensions separately and also their interactions as the unified whole with the use of Spatial Grasp Technology (SGT) and its Spatial Grasp Language (SGL), already tested on numerous applications. One of possible applications of this project, considered here, relates to the disputes between different states, and especially in solving territorial problems on their borders, which may result in prolonged contests, rivalries, and even military engagements. The descried scenario, and its possible solution with the use of SGT and SGL, involves two countries sharing the border between them, with one containing border-close region which it considers as own territory, while the another one disputing this region and demanding its back, motivating this historically. The dynamics of this competition is described with the use of three spatial dimensions (one battlefield-physical, and two planning-managements as virtual). It is also shown how to evaluate the success or failure of this campaign from both conflicting sides using the related dimensions, which can dynamically substitute or supply additional fighting units, if necessary. Some broader assessment of how to continue may be coordinated by public opinions from both sides, which can be effectively collected using spatial networking social coverage in SGL. The paper also highlights the necessity of using additional spatial dimensions, including economic, political, cultural, and historic ones, to resolve such complex crises in most effective and general way, as we often witness in many known situations throughout the real international world.

Keywords: multidimensional world, international rivalries, Spatial Grasp Technology, Spatial Grasp Language, multidimensional project, overlaying and interacting dimensions, collective spatial solutions

1. Introduction

We are starting with some definitions related to the current area of investigation, which may be named, expressed, and explained as follows.

International territorial rivalries are enduring disputes over sovereignty, with over 188 areas globally under contention as of early 2026 (https://en.wikipedia.org/wiki/List_of_territorial_disputes). International multidimensional rivalry refers to the complex, simultaneous competition between states across several overlapping spheres—primarily political, economic, technological, security, and normative domains (Perthes, 2021). International territorial disputes are disagreements between sovereign states over the control of land, water, or airspace, frequently causing regional instability or armed conflict (https://en.wikipedia.org/wiki/List_of_territorial_disputes). A multidimensional territorial fight refers to a conflict over land or space that is driven and shaped by a complex interplay of multiple layers beyond simple physical boundaries, including geopolitical, economic, cultural, and digital factors (Kim, 2020). A multidimensional territorial victory refers to a strategic success that is not defined solely by the seizure of land through conventional military force, but by the simultaneous achievement of objectives across political, informational, and social domains. In modern conflict, particularly irregular or hybrid warfare, establishing physical control is often secondary to sustaining resilience, legitimacy, and long-term political stability (Fernandez-Osorio, & Upadhyaya, 2025). Spatial management of multidimensional confrontation, the closest one to the current paper, refers to a high-level approach for investigating and controlling complex systems that span both physical and virtual dimensions. This framework treats global challenges, such as distributed warfare, environmental disasters, or political conflicts, as spatial problems that can be managed through networked representations and collective solutions (Sapaty, 2026). Many more publications from these and related areas can be found, (Núñez, 2026; Fan, Kuang, *et al.*, 2026; Thompson, Sakuwa, *et al.*, 2022; (https://en.wikipedia.org/wiki/Territorial_dispute; Kapitsinis, & Metaxas, 2012; https://diplomatonline.com/2019/09/disputed-territories/; Judge, 2024; Musolino, & Volget, 2020; Subra, 2012) including.

The *aim of this paper* is to show how using the multidimensional world representation and the developed Spatial Grasp Model and Technology, effectively covering the whole world, to explain, model, and manage complex international rivalries linked with the disputed territories.

The rest of this paper is organized as follows. Section 2 describes basics of Spatial Grasp Technology and multidimensional management project based on it. Section 3 considers the investigated territorial dispute problem. Section 4 describes initial stage of the conflict. Section 5 shows dynamics of multidimensional territorial fight, with engagement of three spatial dimensions. Section 6 describes how to add new or substitute damaged units from both conflicting sides. Section 7 shows how to evaluate the success or failure and complete this multidimensional territorial fight. Section 8 mentions other distributed dimensions engagement of which may be useful for solving complex international disputes. Section 9 concludes the paper confirming effectiveness of the developed spatial technology for description and management of complex international conflicts. References mention the used publications on multidimensional conflicts and the spatial grasp technology engaged.

2. Spatial Grasp Technology and Multidimensional Management

Within Spatial Grasp Technology (SGT) (Sapaty, 2026; Sapaty, 1999; 2005; 2017; 2018; 2019; 2021; 2022; 2023; 2024; 2025; 2026), a high-level operational scenario expressed in recursive Spatial Grasp Language (SGL), starting in any world point or points, propagates, covers, and matches the distributed environment in parallel wavelike mode, as symbolically shown in Figure 1. Such propagation can result in returning and analyzing the reached states and data, which may be arbitrarily remote, or to be used for launching more waves, also jointly in both cases.

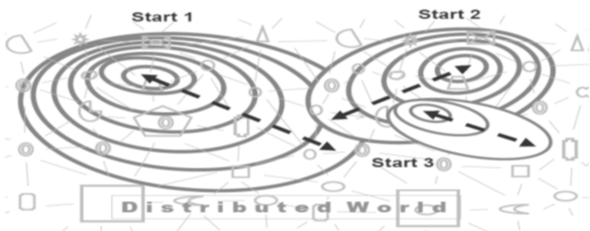

Figure 1. Parallel recursive world coverage with Spatial Grasp Model

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), as well as their combinations.

SGL allows for organizing direct space presence and operations with unlimited powers and parallelism. Its universal recursive organization, with operational scenarios called *grasp*, can be generally expressed as:

$$grasp \rightarrow constant \mid variable \mid rule\ (\{grasp,\})$$

The *rule* expresses certain action, control, description or context accompanied with operands, which can be any *grasps* too. The rules, starting in certain points, can organize navigation of the world sequentially, in parallel, or any combinations thereof. They can result in the same application points or cause movement to other world points with obtained results left there or returned. The final points reached can become starting ones for other rules. The rules, due to recursive language organization, can form arbitrary operational infrastructures expressing sequential, parallel, hierarchical, centralized up to fully decentralized and distributed algorithms. The SGL interpreter serves currently associated SGL scenarios or their parts, also organizes exchanges with other interpreters for distributed SGL solutions. Different international areas have been successfully investigated under SGT with the help of SGL Sapaty, 1999; 2005; 2017; 2018; 2019; 2021; 2022; 2023; 2024; 2025; 2026).

The following examples and solutions of this paper relate to the Multidimensional Management Project (MMP), currently in development, with its general view depicted in Figure 2 (see also (Sapaty, January 2026; 2025; 2026). The project consists of overlaying and communicating sections of spatial dimensions and Global Management (GM) facility, allowing altogether for entering, analyzing, and optimizing different dimensions and their interactions as the unified whole.

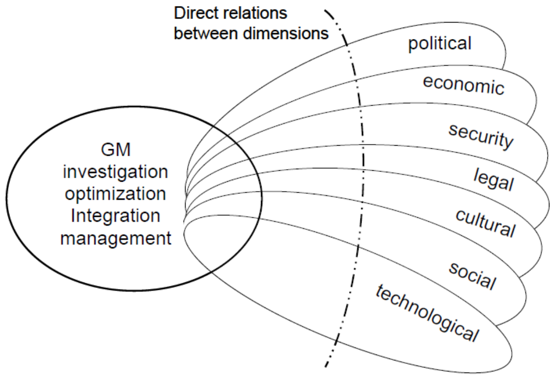

Figure 2. Multidimensional management project

SGL, with its special version, is the basic language of MMP, which allows for clear and very compact solutions of complex spatial and communication problems in both physical and virtual world dimensions, their intersection and interdependence, as well as holistic integration.

3. The Problem

Imagine two countries **A** and **B** share the border between them, as in Figure 3. **B** contains the border-close region which it considers as its own territory. However, **A** disputes this region and wants its back, motivating this historically. This region is protected inside by security and military *defending* units from **B**. On the other side, **A** deploys its own *attacking* units in a desire to penetrate and conquer the region.

Figure 3. The territory problem

4. Initial Stage

The initial multidimensional picture of this contest is depicted in Figure 4, with dimension **D1** supporting country **A, D2** as contextual physical world dimension, and dimension **D3** supporting country **B**. The deployed *attacking* units from D1 for A are in red, and *defending* units from D3 for B are in green.

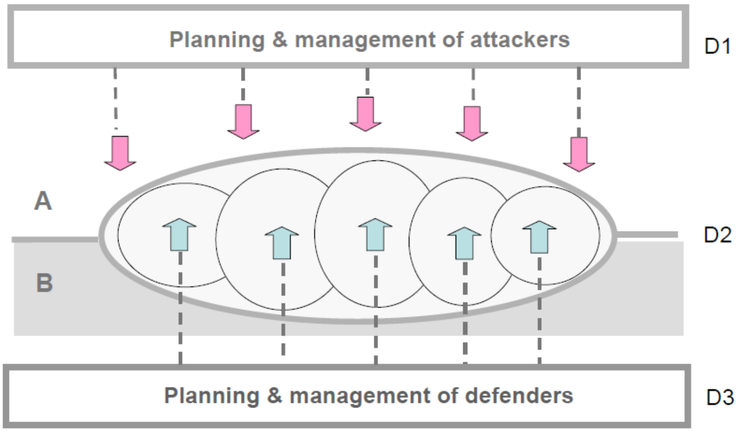

Figure 4. Initial stage of the conflict

The initial stage of the conflict with operational units installed from both sides in advance may be organized as follows.

<u>In **D1** for **D2** and **A**.</u> Beginning from the leftmost *start* point of the region's border, **D1** sequentially installs towards the *right* certain number of *attacker* units along the region's border, in *step* distance between them, until reaching the rightmost *end* border point. In SGL this can be expressed as:

frontal(Region = ...); go(*start*);

repeat(install(*attacker*, WHERE); go(Region, border, *right*, *step*);

if(close(WHERE, *end*), stop))

<u>In **D3** for **D2** and **B**</u>. Inside the disputed region, **D3** installs in parallel certain *number* of security or *defender* units, randomly distributing them throughout the whole region. In SGL this will be as:

Region = ...; go(*number*_random_points(Region)); install(*defender*, WHERE)

5. Dynamics of Multidimensional Fight

This is a complex situation for both sides, and each forms is own planning, supervision and management (virtual) dimension for pursuing own interests, like **D1** by **A** and **D3** by **B** (generally operating as advanced self-organized distributed networks), whereas the physical conflict area is represented by dimension **D2**, as in Figures 4 and 5.

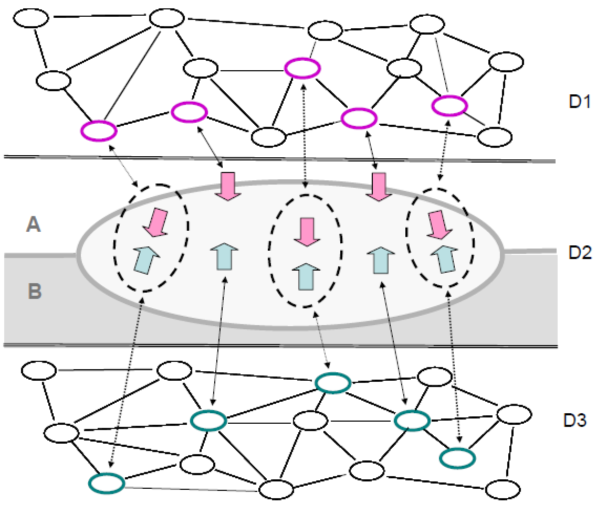

Figure 5. The conflict development under interacting dimensions

Figure 5 also shows a possible intermediate state where units from both sides in **D2** are attacking and trying to destroy the opposite ones, with spatial management of this dynamics performed by frequent communication of individual units with related networked points in **D1** or **D3**, with details following.

5.1 Interaction and Cooperation Between D1 and D2

For example, the swarm of attackers can be provided with fully distributed global awareness. This global awareness quality may be naturally embedded into the communicating attackers, where targets seen by individual units are regularly exchanged with their neighbors, enriching their awareness. And these neighbors, of all they know and see, exchange with their neighbors too, and so on, as in Figure 6.

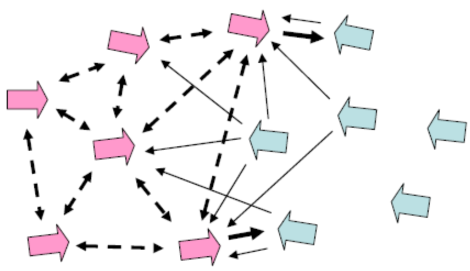

Figure 6. Collectively advancing attackers with distributed global awareness

This makes all swarm members gradually aware of all targets in the region, despite not all of them visible individually, and always organize their movement in proper direction, first to be closer to the targets, and then to destroy them. An example of such SGL solution may be as follows, which will need effective interaction between **D1** and **D2** dimensions.

In **D2** for **A**

hop_*attackers*(all);

repeat(select_move_destroy_remove(Targets))

In **D1** for **A**

frontal(Region) = ...;

hop_*attackers*(all);

repeat(

merge(Targets, search(Region, *distance*));

merge((hop(neighbors_*attackers*); Targets), Targets))

5.2 Interaction and Cooperation Between D2 and D3

The swarm of defenders can also be with **centralized and migrating global awareness**. We may provide the higher-level awareness operating autonomously and independently over the basic swarm organization. Initially applied in any swam node, it will be capable to contact all nodes in parallel, collect all they see, and then distribute to all nodes this global vision, in parallel too, as in Figure 7.

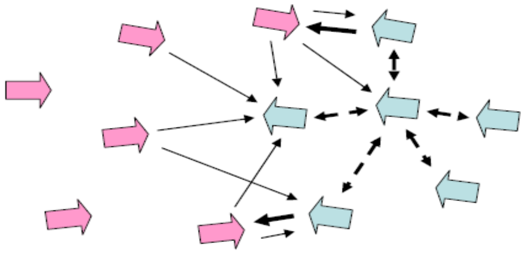

Figure 7. Collectively fighting defenders with centralized global awareness

The focus of such superior consciousness may be constantly migrating between the chasers for security reasons, and the solutions for **D2** and **D3** in SGL may be as follows.

In **D2** for **B**

hop_*defenders*(all);

repeat(select_move_destroy_remove(Targets))

In **D3** for **B**

frontal(Region = ..., Global);

hop_*defender*(Region, any);

repeat(

Global = merge(hop_*defenders*(Region, all); Targets);

stay(hop_*defenders*(Region, all); merge(Targets, Global));

hop(Region, any_*defender*))

Also for higher security and survivability, where each defender unit can be potentially damaged or destroyed any time on a battlefield, we can introduce and operate many such migrating awareness centers in parallel. This will always guarantee capability of this superior awareness with any number of remaining units.

6. Substituting Damaged and Launching Additional Fighting Units

The modeling and management of this three dimensional world may need further details for this conflict description, like dynamically invoking more operational units from both sides and providing more addvanced collective behavior of multiple units, as in previous publications. Elementary examples are following.

For **D1** and **A.** If the currently operating number of attackers lower then the number of defender by a given *threshold*, then install additional attackers into the region with their number defined by this difference, also with a special coefficient, as follows.

```
repeat(
   Numb1 = count(hop(Region, attackers, all));
   Numb2 = count(hop(Region, defenders, all)),
   if(Diff = (Numb1 – Numb2) < threshold1,
        go((Diff * coeff1)_random_points(Region)); install(attacker, WHERE));
   sleep(delay1)
```

For **D3** and **B**. Similar procedure can be for installing addition defender units for B from D3, as follows.

```
repeat(
   Numb1 = count(hop(Region, defenders, all));
   Numb2 = count(hop(Region, attackers, all)),
   if(Diff = (Numb1 – Numb2) < threshold2,
        go((Diff * coeff2)_random_points(Region)); install(defender, WHERE));
   sleep(delay2)
```

These dimensions D1 and D3 can carry much more detailed and intelligent functionalities, as symbolically shown in Figure 8.

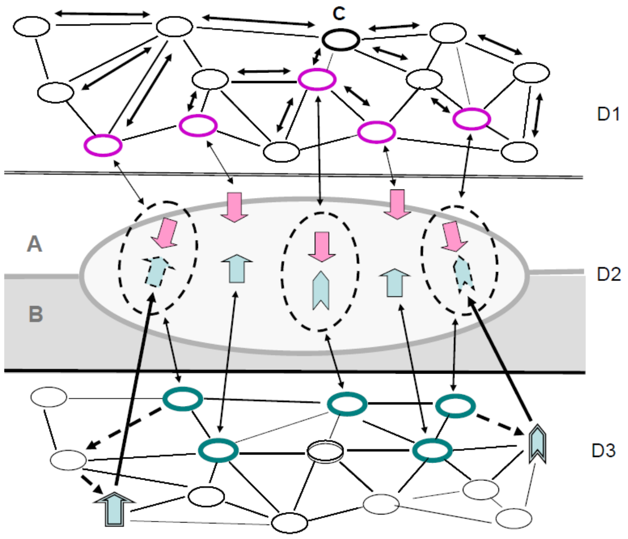

Figure 8. More activities in Dimensions D1 and D2

For example, D3 can also contain known production and storage of defender units, which can dynamically substitute particular units destroyed at the battlefield, like in Figure 8. As states and locations of each unit are constantly controlled from the related nodes of D3 network, their loss will be immediately discovered, and their controlling nodes can immediately search for storages of their types via the distributed dimension network (which can be both virtual and physical). And after finding them, D3 can directly organize finding and direct transfer of the physical substitutions of damaged units directly to the battlefield locations needed.

```
frontal(Defender = unit(type, state, loc = WHERE));
repeat(
   update(Defender);
   if(destroyed(Defender(state),
        repeat(hop_first, neighbors);
                 if(TYPE == Defender(type),
                     pick_install_activate(Defender(loc)))))
```

7. Possible Final States

A possible resultant state of this scenario is shown in Figure 9, where country **A** supposedly defeated country **B**, having resultant own units capable to see and control the whole region, and **B** not having units there, as all destroyed by the advancing units from **A**, as follows in SGL

For **D1** and **A** (as in Figure 9):

If(count(hop(Region, *attackers*, all)) > *threshold3* and
    count(hop(Region, *defenders*, all)) = 0,
    declare(VICTORY))

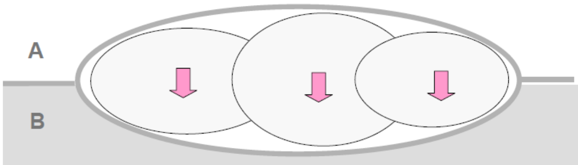

Figure 9. Indication of victory for A

Another possible resultant state of this scenario is shown in Figure 10, where **B** supposedly defeated **A.**

For **D3** and **B** (as in Figure 10):

If(count(hop(Region, *defenders*, all)) > *threshold4* and
    count(hop(Region, *attackers*, all)) = 0,
    declare(VICTORY))

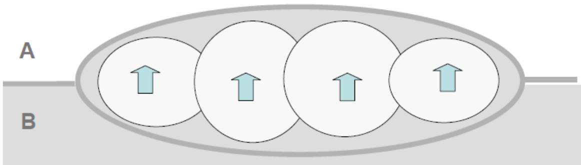

Figure 10. Victory indication for B

In reality, the dynamics in Figures 5, 6, 7, 8 may lead to quite different solutions, like, for example, where neither side could report victory. The networked dimensions **D1** and **D3** can potentially provide highly intelligent assessment, planning and management of the ongoing situations, and the final solution may not be easily reached even in predictable time.

For example, declaration of the victory or defeat may strongly depend on the country's public opinion about the necessity to prolong the war (say, by analyzing and comparing the current numbers of own and adversary units by many citizens). The averaged collection of global public opinion in country **A** throughout the **D1** network with the center node **C** (see Figure 8), can be organized as follows, with **A** declaring defeat and withdrawing remaining own units if believes that the war prolongation has no sense any more, otherwise continuing the operation.

hop(C);

frontal(State) = append(count(hop(Region, *attackers*, all)),
    count(hop(Region, *defenders*, all)));

Opinion = average(repeat(hop_first(neighbors); fin_free(opinion(State))));

if(Opinion < *threshold*, (withdraw(hop(attackers, all)); declare(DEFEAT)))

In a similar way, public opinion can be collected, summarized, and averaged for the country **B** throughout the distributed network in dimension **D3**.

8. More General and Global Multidimensional Solutions

In the broader sense, finding realistic suitable solutions may also need additional engagement of economic, political, cultural as well as historical dimensions to solve such crisis either way, as we often witness in similar situations in the real international world. In short, these dimensions can be defined and explained as follows.

The economic dimension refers to the financial, market-driven, and productive aspects of an entity, system, or development, focusing on viability, growth, and efficiency. It involves managing resources, generating income, and addressing financial impacts such as profitability, employment, and market competition within a specific context (Featherstone, & Ginsberg, 1996). The political dimension refers to the ways power, influence, and decision-making are established and used within any given subject, organization, or society. It involves the dynamics of how groups or individuals manage resources, implement rules, and influence outcomes through formal institutions or informal interactions (Leach, Stewart, *et al.*, 1994). A cultural dimension **is** a measurable aspect of a culture that can be compared relative to other cultures, providing a framework for analyzing values, behaviors, and social norms (Kole, 2024). A historical dimension **re**fers to the context that considers how events, concepts, or systems have evolved over time. It involves analyzing the origins, development, and continuity of a subject to understand its current state and potential future (Rimmer, & Dick, 2013).

These and other dimensions, which are potentially distributed and spatial as covering the whole countries, can be represented and managed separately and in any combinations under the basically spatial and distributed SGT and SGL, which have been already tested in numerous world areas by the previous publications, (Sapaty, 1999; 2005; 2017; 2018; 2019; 2021; 2022; 2023; 2024; 2025; 2026) including.

9. Conclusions

The paper considered the necessity to analyze and explain fundamental nature of international contests, rivalries, and fights as interaction, intersection, and integration of different physical and virtual dimensions. It also confirms the suitability of the developed SGT-SGL paradigm for investigating and modifying different conflict dimensions and their holistic integration and management, where effective operations for communicating dimensions can be organized in parallel and fully distributed mode. And the solutions in SGL may be simpler, more powerful, and much more compact than with traditional models and languages. It also mentions that in the broader and global sense, finding suitable international conflict solutions may need additional engagement of more physical and virtual spatial dimensions, including economic, political, cultural and historical ones, which can also be effectively covered and managed by the spatial model and technology developed. Some broader assessment of how to continue the dispute may be coordinated by public opinions from both sides, which can be effectively collected using spatial networking social coverage in SGL, as was shown in the paper.

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