

A FRACTAL APPROACH TO SUSTAINABLE NETWORKS

Abstract

This paper qualitatively illustrates how and why interdependence becomes significant in building coherent and sustainable network systems based upon human flourishing. Ethnographic case data of an icon tourism destination is provided to examine the structure, process and patterns that are essential for understanding network organisation. The notion of fractals has been applied to more deeply understand the multi-dimensionality of networks. Through the fractal characteristic self-similarity, the data revealed aspects of volume-filling, reciprocity and enfoldment that were central to the transforming power of network organisation.

Behind the divisible there is always something indivisible.

Behind the disputable there is always something indisputable.

Chuang-Tzu

Introduction

In the world of measurement and deduction, objects are separated into small detail in order to be understood through a quantifiable process of analysis, known as Cartesian and Newtonian scientific approaches. While the outcome of these mainstream approaches has been an industrial revolution of scientific innovation, the disconnect that results from this separation remains consequential (Bohm, 1980). For example, our earth is organised by a string of social, ecological and environmental connections between people, place, space and other life forces. Production of our own food, clothing, warmth and shelter connect us intimately with the cycles of nature. However, our modern industrial system has disconnected us from our environment and we have lost this intimate awareness. Conventionally we see nature as something to be controlled, as a malevolent intrusion on our world, with potentially disastrous consequences that may emerge from this absence of intimate awareness (Snyder, 1990).

Thus, we need additional lenses to understand this interconnected world of relationships, processes, patterns and context that Capra (2005) claims are central to the coherence and integration of network systems. Yet our knowledge of such complementary approaches is emergent and raw. Drawing on the new science of complexity, this paper examines fractals as one possible perspective that may assist us in understanding how the intimacy of interdependent processes are not only connected but are also self-organising and mutually constructed. Fractals demonstrate patterns of interconnection, and while they are primarily mathematical models, this paper applies the fractal concept to an organisational context to *qualitatively illustrate how and why interdependence becomes significant in building coherent network systems*. This paper identifies themes from a review of fractal literature and illustrates how they apply to an organisational network system. The contribution from this paper is its translation of hard science into an 'observable reality'.

Network Interdependence

Networks are claimed to be a defining contributor in reshaping our social communities in the 21st century (Parkhe et al., 2006). Yet their complex multi-dimensionality has signalled the inadequacy of our current linear and predictive theories (Galaskiewicz, 2007). In most network analysis, there is a preoccupation with structure (the nodes and connections) through the relations amongst actors and their individual positional location. These 'measurement' orientations designate a group of relationships that are fixed and controllable which are contrary to the distinctive characteristics of networks. Rather, their plural pathways whereby information is transmitted through any possible connecting point (as opposed to more vertical and horizontal forms in hierarchies) (Powell et al., 2005), their nodal complexity whereby networks become interdependent based upon complementary resource transfers obligating one organisation to another (Uzzi, 1997; Gulati, 1999) and the fluidity that emerges from this structural complexity when partners 'switch on the dance floor' (Powell et al., 2006), each indicate complex, flexible and non-linear modes of self-organisation.

Conventional network analysis then, displays little acknowledgement of dynamics, of the fluidity emerging from the connecting points and of the 'empty space' within which the network resides. Process is assumed to be determined by structure "and there is no sense in which the mutuality of pattern, process and structure is accommodated" (Lowe, forthcoming: 54). The current state of network analysis therefore generally avoids examining these interrelationships that Capra (2002) claims are central to the practice of organising, primarily because of the difficulty in capturing them for analysis. Lawler (1982) adds further support as to why this difficulty exists by highlighting that our European languages have no linguistic form related to processes that do not have material carriers, such as the words pure, quality and even God. Our words require that verbs always be associated with nouns. This helps to explain why our western science too struggles to acknowledge and clarify such integrating and holistic processes as the immaterial.

The purpose of this research then is to more deeply understand the interdependent multi-dimensionality of networks. What is the relationship between structure, process and

pattern? How do they impact on the organising mechanism of the network? And how does self-organisation within the network allow us to understand the quality of the system? Understanding this more complex and multidimensional form of organisation therefore requires qualitative approaches that embrace this non-linearity and complexity.

Process, Pattern and Organisation

Within this inquiry, we observe the metaphysical assumption that network nodes “become more like markers around which dense networks of relationships are acted out instead of fixed objects which predetermine our mental and physical movement” (Cooper, 2005: 1691). The focus of examination therefore, is on the realisation of the network through process, pattern and structure. Following Capra’s (2002) claim that process is the ‘bringing forth’ of a reality, this inquiry considers how this engagement is enacted to create networks of sustenance that include economic, social, environmental and spiritual co-dependency.

While sociologists have long examined the role of reciprocity and obligations as part of the organising norms in society (Granovetter, 1985), in management literature on networks these features are noted but not universally prioritised (Ibarra, 1992). Yet norms of reciprocity are essential if we are to engage in ecological networks for sustainable futures. Turner (1995: 45) notes that we must take our “residence in a biological order; to become whole we must live as part of a larger system of plant and animal communities governed by reciprocity”. This more system-based approach means that the norms and rules of collaboration, reciprocity and interdependence become inherent in their self-organisation. The whole is emphasised more than the parts, with recognition of the intrinsic values of all that inhabit the system as an interdependent web of life (Naess, 1973).

This gives rise to the importance of the network system as a unit of analysis, with it enabling us to more closely observe the patterns of interconnection that emerge from process within the context. While not intending to give primacy to the structure as a fixed and objective reality, it does provide a physical configuration for conveying the movement of energy within the system. The patterning, Capra (1997: 167) defines is “the configuration of relationships that gives a system its essential characteristics. Thus, the patterns illustrate the qualitative configuration and organisation of relationships.

Fractal Organization

The focus, then, is on the patterns that emerge from the network configuration, and fractals provide a language for understanding this qualitative nature of self-organisation. Fractals are geometric shapes that provide a lens to study spatial order through the relationships that form from patterns of interconnection, indicating how fluidity and movement can be viewed multi-dimensionally. The pattern then is illuminated through the fractal shape and becomes significant in creating form to the relational system through its spatial multi-dimensionality. As Lawler (1982: 5) suggests, “the content of our experience results from an immaterial, abstract, geometric architecture which is composed of harmonic waves of energy, nodes of relationality”. This reinforces the multi-dimensionality of the interconnected system necessary when thinking in ecological terms, and the bonding of the material world and the spaces in between. Capra (1991: xi) too brings to our consideration that “all forms are associated with processes, all interrelations with interactions, and opposites are unified through oscillations”. These oscillations highlight the movement and change that becomes of primacy of network organisation.

Conventionally, fractal is the measure of the irregularity of the shape of an object: it is neither a straight line nor a smooth curve. Based upon mathematical equations, fractals allow examination of irregular forms, thus critiquing the ‘measurement’ paradigm of fixed and stable points. The common analogy of fractals is the measurement of a coastline, which becomes greater with increasing precision as you take into account ever smaller irregularities along the length. Popularised by Mandelbrot (1983) who worked hard to demonstrate that fractals have application in the real world and were not just a mathematical curiosity, they are also seen in nature as ferns, twigs, cauliflowers, broccoli, clouds and ocean waves. Their central characteristics are that they are a) irregular all over, b) have the same degree of irregularity on all scales, and c) look the same whether examined close up or far away. Thus, fractals are shapes that are systematic even when their components are uncertain in outcome and form. Their rules governing growth ensure that small-scale features become translated into large-scale ones which indicate the forms of stability that inherently reside within the system. By successively magnifying a part of the whole reveals a further structure that is nearly a copy of the original.

The fractal concept therefore enables us to explore the notion of quality as it represents the dynamics of the whole, whereas measurement examines the parts. The following case discussion examines these ideas in depth through empirical data. The paper then offers insights into how fractal patterning can assist in further understanding of network interconnection for creating systems of co-creative sustenance.

Method

This paper examines these premises of structure, pattern and process as organising mechanisms in a case study of an icon tourism destination in New Zealand, the Waitomo Caves, famous for its underground caving activities and attractions. While tourism began in 1887, the focus for 100 years was mostly on the Glowworm Cave with its imposing limestone formations, and a float through the cave-stream viewing its famous fauna, the glowworms, which twinkle like a universe of stars in the darkness. Yet a history of exploitation by the State owned agent, the Tourism Hotel Corporation, stymied the development of the destination. By the late 1980s, however, a growing number of younger people were coming to New Zealand as free and independent travellers, and this pre-empted the development of a complementary production system based around adventure caving. These six hour caving trips necessitated additional symbiotic interdependencies among the primary and support activities, food and overnight accommodation providers to cater for this market. The development of this small but comprehensive network system brought significant changes to the destination, and for the first time enabled complementary knowledge flows to exist. Only the core tourism product, the Glowworm Cave, has independent corporate management and the other organisations are locally owned. They vary in size from the Glowworm Cave with 70 employees at the height of the summer season, to mid-range adventure operations with 30 employees, to micro-owner/operated organisations.

This context is significant for analysis in that its geographic isolation provides some limitations for a study on a network system. Further, it relies upon the sustainable management of its fragile environment, and thus, economic, social, environmental and also

spiritual imperatives that emerge from the indigenous cultural traditions embedded in the landscape are present in its organisation. This makes the network itself a multi-dimensional and complex integration of imperatives rich for this form of study.

The paper builds on earlier ethnographic work that identified a series of collaborative groupings that emerged from the thematic analysis of case data collected over a five-year period, 1996-2000. The data collection process included formal interviews with each of the twelve owner/managers of each firm within the destination each year, plus an additional eight associated external institutions. In accordance with ethnographic research, a significant amount of archival documentation, informal conversations and personal observations also comprised the data collection. A further follow up study in 2007 was undertaken to give a 10 year history of collaboration in the destination. This included a small questionnaire to each organisation examining their six most strategic partnerships, both within or external to the destination, and a second set of questions regarding the economic status of their business. Currently, 15 of the 24 organisations responded, and the following preliminary data are based on these responses. Further qualitative interviews were also conducted with key organisations, both within and external to Waitomo.

The analysis in this paper conforms with an 'abductive' process whereby one begins with fragments of understanding, and then one builds more holistic pictures of an observable reality. This form of 'invention' includes acts of faith, as abduction forms the "rules that are postulated to explain the observed facts" (Weick, 2006: 1731). As Shotter (2005: 4) notes, "it is not a matter of acquiring some new information or data, but of redirecting or reorienting our attention, to noticing things which no-one has doubted, but which have escaped remark only because they are always before our eyes".

The Network System

With this research inquiry focusing on the patterns that emerge to more deeply understand network organisation, mapping of the data were significant to illustrate these configurations. As noted earlier, this context has a history of exploitation. However, Figure 1 illustrates significant growth in new business development over the last 20 years, with the

network now sustaining a rich diversity of core, supporting and external firm interconnectivity. This map is intentionally portrayed from a holistic perspective to illustrate the collective integration of the system, the purpose of which will emerge in the discussion section. The full acronyms are included in Appendix A.

Insert Figure 1 here

Alongside this structural change in the context over the last 20 years is also substantial increase in the diversity of external connectivity. This diversity has been identified as significant in integrated networks, as they not only allow plural pathways of information transfer but are also strategically important in assisting complex specialised knowledge to be accumulated (Powell et al., 2005). The density of relationships indicate the fluidity and movement within the network through the informal 'comings and goings' among suppliers (economic and social relationships), employees (economic and social relationships), the broader community (social, environmental and spiritual relationships), external institutions (economic, regulatory and environmental relationships), and visitors (economic and social relationships). It is the density of these diverse types of activities and relationships within the network that form the multi-dimensional patterns that underlie its organisation. Further, this growth in business development is also represented in the increase in economic contributions: from \$3.5million in 1985, to \$9million in 1995, to \$23million in 2005.

Collaborative groups

It is this multi-dimensionality that now becomes the focus of this paper as it relates to non-linear organisation and system-related sustainable outcomes. Predicating this discussion on fractal organisation, a brief description of the collaborative groups that emerged from the earlier data analyses is given to set the context to explore network interdependence and ecological sustainability. While other collective groups emerged from the data, in this paper the three examples illustrated as they relate to sustainability are: Landcare, adventure risk management, and underground karst management.

- Above-Ground Landcare

The first and most robust of these collaborative groups was the above-ground Waitomo Landcare Group which was formed in 1992 after mounting community concerns regarding the environmental degradation of the underground caves and the inadequate management procedures. These karst environments are recognised for their 'twin landscapes', as activities occurring above the ground can impact on the underground system. For example, roading improvements can result in flow-offs into the river streams, and this silting can cause cave erosion, fauna damage, and glowworm disruption in areas some distance from the initial activity. These negative impacts have the potential to destroy the limestone cave formations, the glowworm populations in the caves, and the economic viability of the tourism destination.

Facilitated by the Regional Council, Environment Waikato (EW), the group included the local farming community (donating land to be fenced and replanted), tourism operators (contributing financial inputs), community members (providing voluntary labour) and other outside knowledge-based institutions (Waitomo District Council, Department of Conservation, and universities). The purpose of the Landcare Group was to protect the Waitomo Caves system from sedimentation through appropriate and sustainable land management practices. Collaboration among these internal and external stakeholders included fencing off the waterways and forest replanting programmes, primarily to improve water quality for sustaining glowworm populations and the cave environment. The group is promoted nationally as a 'best practice' example of a Landcare group with a 60% reduction in sediment loading in the Waitomo stream, less soil erosion, and over 500 hectares of bush now protected. Its initial purpose of improving the longevity of the cave environment has been achieved, and the participation of the community has resulted in widespread consensus and acceptance of the land management practices to sustain the destination environment. The pattern of connection is illustrated in Figure 2.

Insert Figure 2 here:

- Adventure Risk Management

The second collaborative group involved managing the visitor risk attached to the underground caves. Given that they are dark, cold, wet and often confined spaces, the

ability to manage these potentially risky and dangerous situations requires an advanced standard of guiding to ensure client safety. Some of these adventure activities involve abseiling, floating in the underground river streams, and clambering around limestone rocks. Organisational collaboration in Waitomo around this issue has led to several outcomes. First, the informal information exchanges among operators and employees (i.e. after-work drinks at the local tavern) resulted in better safety practices being developed for managing operational risk. From these exchanges and concerns, the Waitomo Caves Rescue Team was formed, with specialist guides from the adventure caving organisations working together in emergency situations – most commonly arising from situations involving recreational cavers. Finally, the adventure caving organisations in Waitomo have been instrumental in building national caving standards throughout New Zealand, as their Waitomo-based collaborative systems and standards (Waitomo Rope Standard Technique - WRST) have been incorporated into institutional frameworks (New Zealand Qualifications Authority, Sport Fitness Recreation Industry Training Organisation and the New Zealand Outdoor Instructor Authority). Thus, these organisations are seen as adventure sector leaders in New Zealand with local knowledge spilling into the larger institutional education framework and in the broader tourism industry (Adventure Tourism Council, Tourism New Zealand). This pattern of interconnection is illustrated in Figure 3.

Insert Figure 3 Here

- Underground Karst Management

Finally, a third area of emerging collaboration that has not yet attained an integrated focus, is that of underground environmental management (illustrated in Figure 4). While there has been access to ‘weak-tied’ external knowledge for decades, the restrictive administration practices of the previous central actor (Tourism Hotel Corporation) stymied any development of knowledge-building in this area. Committed investment into processes, practices and analysis of underground cave management has only occurred over the last ten years in the Glowworm Cave (GWC). Currently, other members of the community, such as tourism operators using other caves, are becoming involved. Together these organisations are endeavouring to form a system of managing the interdependent karst context – humidity, glowworms, carbon dioxide levels – building a data-base of systems, practices and

experiences that can restore the environmental habitats. These linkages are primarily internal ties, and again the limited nature of these ties demonstrates the absence of flow in building strategic capabilities.

Insert Figure 4 here

In the original analysis of these data, these were the most significant of the collective groups and they relate to knowledge specialisation that does not emerge when only focusing on commercial-related questioning. Thus, like the landscape, they were beneath the surface, and yet are fundamental to providing sustenance to this destination. Both the Landcare group and underground monitoring include both environmental and social imperatives. Interdependence is evident in the adventure risk management group as it has the potential to tarnish the reputation of Waitomo through any serious accident. For instance, if heavy rain falls, the river level can rise by over one metre within an hour – such conditions need to be carefully monitored. Spiritual imperatives too are evident in this landscape through the ‘waahi tapu’ – places that are locally known as sacred and have to be honoured as such. This has meant finding alternative avenues for commercial activities in order to not disturb these sacred sites.

Thus, the implications of identifying these groups are that they include imperatives other than solely economic, and provide more holistic ways of management than lineal models conventionally applied.

Fractal Organisation

This section discusses a number of insights on fractals that emerged from the data regarding the searching for a deeper understanding of network self-organisation.

Patterns as structure

First, the figures above illustrate the density of nodal connection within each of the collective groups, illustrating the complexity and quality of relational connectivity. Figure 4 depicts limited connectivity, both within Waitomo and with external institutions, and the

consequence of this has been restricted knowledge creation around underground monitoring processes. In comparison, Figure 2 illustrates a relative complexity of agents, resource complementarity, and reciprocal information sharing. Waitomo Landcare is New Zealand's most acclaimed landcare group with significant specialised knowledge and routines now residing within the community. The third pattern, Figure 3, illustrates interdependence, and demonstrates the development of specialised knowledge on risk management stemming from within the destination and flowing into a broader community. Mutual interdependence in the destination is evident whereby a single action by one firm can implicate the safety of visitors underground with disastrous consequences on the reputation of the whole network. Fortunately, in this context, there has been significant responsibility taken to ensure competent and professional delivery of services, lead by the core organisations in the destination.

These patterns, therefore, give us insights into the relational connectivity within the context and from this we can induce the extent of multi-dimensional connection within the network. This is significant as Lawler (1982) claims it is the intensity of these patterns that determine the quality of the system. This suggests that reciprocal information flows around multiple issues have the potential to add intensity into the network; that is, the process of collaboration facilitates complex structural patterns within a context. Deleuze and Guattari (1987) define these multi-dimensional configurations as 'multiplicities', in that they emerge in any form, in any direction and from any point. Thus, they are multi-dimensional and this heightens our understanding of non-linear organisation.

Fractals and enfoldment

In the second insight, Figure 1 illustrates a holistic pattern of interconnected organisations, and the above multiplicities become the fractal sub-sets *enfolded* within this (Figures 2-4). They take on a fractal form because unlike quantitative measures where the concept of (intrinsic) length makes little sense, fractals identify notions of (relative) length measured at any given resolution qualitatively (Sornette, 2004). Thus, fractals embody the qualitative expressions of the network through the relative intensity of their connections. With the characteristics of fractals stemming from self-similarity, these are clearly evident in the patterning of land care, adventure risk and underground monitoring: the same core

organisations belong to each of these multiplicities; there are overlaps in the specialised knowledge activities regarding the identity of the tourism destination (e.g. caves, management of people, tourists, short stays, interdependence on primary and secondary activities); and the expression and identity of the iconic Glowworm Cave that acts to pull visitors to Waitomo is embedded throughout the network.

These patterns then, demonstrate fractal characteristics that are self-similar (whereby an infinite number of smaller shapes can emerge, each still resembling the whole), multi-dimensional, and formed through iteration whereby although the copying of the pattern may become more complex, each still retains core attributes that are observable throughout the network structure. They are self-energising and replicating. Each situation and event always contains an essence of the past and it is this fractal patterning that holds the memory acting as the coordinating mechanism of the network. This implicitly references that the patterns underlying organisation are a unifying force.

Fractal patterns, then, demonstrate the nature of non-linear self-organisation with the same overall structure being maintained despite an ongoing flow and change of components (Capra, 2005). No matter how many multiplicities are developed, there is the same core information inherent in each. Bohm (1980: 224) clearly expresses this in that “each part contains content information about the whole object... that is, the form and structure of the entire object may be said to be *enfolded* within each region”.

This contribution, then, illustrates a cohesion that is demonstrated through organisations with the same resource configurations replicating different activities within each of these collaborative specialisations (fractals). That is, they become *enfolded* within each other and within the overall system. Thus, as Bohm (1980: 222) insightfully continues, “the interactions between different entities constitute a single structure of indivisible links, so that the entire universe has to be thought of as an unbroken whole”.

Volume-filling through process

The third insight focuses on the ‘space’ within which the network resides, and demonstrates that the fractal patterns are created and maintained through reciprocal relations. As noted

earlier, conventional network research focuses on the nodes and connections, yet we now understand that what was regarded as 'empty' space is actually full of excitable energy, and our physical world is merely a small manifestation that emerges from this background of total energy (Bohm, 1980). As Merleau-Ponty (1962: 243) recalls, we were "imaging (space) as some sort of ether in which all things float... [rather] we must think of it as a universal power enabling them to be connected". Lawler (1982: 22) too describes this space as a magnetic field of energy filled with "whirling, fiery bodies from the heavens".

The focus turns to this background energy and its role in organisation through the fractals. All of the illustrated fractals are multi-dimensional. That is, they comprise multiple actors from multiple sectors – with each fractal focused on a specialised activity. They are multi-dimensional in that they are complex. If enfolded into each other there would be some overlap while also considerable extension of diversity beyond the simple pattern. Thus, they become 'volume-filling'. They occupy more 'space'. Network connectivity, then, acts to actualise that latent space, through creating possibility from that universal power of whirling energy into physical form. Turner (2002: 13) claims that such forms "have the odd property of filling up the space available to them with more and more detail, a line densely kinking up to fill a place, or a surface folding up a volume...". This clearly references how the fractal patterns emerging in Waitomo over the last twenty years can be described as 'volume-filling' through their multi-dimensionality, and how knowledge specialisation developed in this context.

Yet how and why did this occur at this time? As noted earlier, the absence of connectivity over the 100 year life of the destination was characterised by limitation and exploitation. With the new network forming in the 1990s, the plural pathways assisted information transfer (Powell et al., 2005), and the *process*, or intention underlying this sharing was central to the transformation of the network. The intention of the previous central actor (1910-1986) was to stymie new business development in the destination, and to extract short term profit, with little investment in the Glowworm Cave over those years. However, from 1987 onwards, more collective intentions emerged from the new actors through a process of inter-sector collaboration that has benefited the network as a whole.

Process, then, becomes central to the organising phenomena of networks, as it facilitates 'volume-filling' from the immaterial through creating coherent fractal patterns that add richness and texture. In this way, when it is argued that fractals represent the quality of the system, this refers to how the quality of reciprocity is reflected through the intensity of the multi-dimensional patterns.

Thus, organisation occurs to space and time within the local context by the connectivity based upon "an invisible and missing wholeness" Cooper (2005, p. 1700). This transformation is dependent on the extent and intensity of local interactions forming durable connections. As this connectivity deepens, multi-dimensional multiplicities form based upon areas of collaborative specialisation. Lawler (1982: 21) reminds us that, "All elements flow out from a central unity in accordance with the law of inversion or reciprocity".

Ecology and multi-dimensionality

The previous sections have presented an argument that network organisation occurs through its fractal patterns of self-similarity. The self-replicating aspect is able to be actualised into physical form through reciprocal relations. This final section argues that more ecologically sustainable networks can be developed through this multi-dimensional approach, through understanding how and why interconnection takes place.

While complexity theory discusses the self-similarity that characterises fractals, Bohm (1980) uses the word *enfoldment* to describe a similar effect. Enfoldment, however, explicitly references that through reciprocity, an essence is retained in the process of connection. This essence connects all living nature. Sheldrake (1981) too notes that systems develop and self-regulate through a cumulative memory that 'knows' how to look (form) and how to act (function). This 'morphic resonance' is realised in a multi-dimensionality not evident in physical form, with this memory becoming enfolded through reciprocal inter-connection.

The multi-dimensional nature of the fractals and their 'volume-filling' action begins to bring that integral coherency, that universal power noted by Merleau-Ponty (1962), to the

surface. The impact of enhancing this implicit 'know-how' is reflected in the case data through the fractal patterns. The *Landcare group* plays a significant role in the environmental management of the above and below landscapes. As noted earlier, considerable community support was given to fence waterways and to replant native bush. The landcare group has also assisted in the protection of the indigenous sacred sites, known as a 'waahi tapu'. It has been the power of connection that has supported the 'enfolding' of increased knowledge specialisation regarding best environmental practices within the landscape, additional economic benefits from improved management of this resource, greater community spirit through their volunteer work with fencing and replanting, and a deeper understanding of the significance of sacred sites. Thus, economic, environmental, social and spiritual imperatives all contribute to the intensity of this multi-dimensional fractal.

Protecting people has been central to the *risk management* multiplicity, and on many occasions the Waitomo search team have been called upon to rescue people trapped in other parts of the country. In 2007, a well known doctor was trapped in a recreational cave for over 48 hours, and more than half of the rescue team were from Waitomo (including a father and son team). As noted earlier, significant development of caving-related standards have stemmed from this context and they are now embedded in many of the national institutional frameworks. Again, this demonstrates the enfoldment that emerges with interdependence stemming from the caving community in terms of specialised knowledge, love of caving and awareness of risk factors.

Finally, the longevity of the tourism destination depends upon the health of the limestone caves and the glowworms. Previously there have been incidents where the glowworm habitat has been disturbed (through altering airflows in the cave), resulting in closure of the cave for four months. Today, this would have significant economic impact on the destination, not to mention on the cave ecology. The scientific *monitoring and research* of this environment now contributes to improved economic and environmental outcomes of the destination regarding relationships between cave hydrology, carbon dioxide levels and climate changes. Yet the embedded memory of exploitation continues to flow through this

fractal, and there is currently significant effort being put to improve the reciprocal exchanges needed to build a more multi-dimensional aspect to this fractal.

These small illustrations highlight how the fractal patterns add intensity and texture to the network to assist in its organising function. Central to this process of organisation has been the multi-dimensionality of connections. The data illustrated that transformation occurred through connectivity, through the creation of multi-dimensional fractals patternings of specialisation within the network. The 'volume-filling' aspect of these were formed by a process of reciprocity, thereby allowing the immaterial to flourish in new forms.

Conclusion

The concept of network organisation through interdependence has been examined in this paper through a qualitative focus on structure, pattern and process that Capra (2002) claims is central to our understanding. A reflective process of abducting from an ethnographic study, allowed the case data to illustrate how fractals offers a complementary perspective in understanding the organisation of complex interdependent networks. More specifically, it qualitatively revealed how and why interdependence becomes significant in building coherent network systems.

The data revealed further essential characteristics of fractals beyond the self-similarity reported in the literature. Characteristics of volume-filling, reciprocity, multi-dimensionality and enfoldment play an important role in our understanding of network organisation. This is significant in that collaboration involving these features create more holistic and ecologically sustaining interdependent network contexts that may include economic, environmental, social and spiritual values to assist in transforming lineal imperatives to more integrated ecologically sound notions of organisation. Central to this is that all interaction is enfolded within each other; that there is no 'out there'. When addressing the notion of organisation, we need to address ecological imprints with a more conscious and deep awareness: its depth, its richness and its presence. As Capra (2002) noted, meaning is formed from patterns of relationships. As we have seen, reciprocity allows richness and intensity to develop, so that we can see the object's depth and its presence. To understand our

relationship with the world as sacred, we need to focus on the unseen and accept that our earth is organised by a string of social, ecological and environmental connections between people, place, space and other life forces. We live in an interdependent web of life where the invisible connections hold a universal power. Our journey is to connect. To conclude, in the words of Lawler (1982: 20):

“We exist in groups, determined by various levels of energetic affinities, repelling, exchanging and absorbing through interconnected subtle energetic communications. We have to learn that there is nowhere that we can dispose of things we have finishing using... everything remains here with us; the cycles of growth, utilisation and decay are unbroken. There is no through away bottle”.

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Appendix A: Key to Waitomo Organisations

Central Cave:

GWC – Glowworm Cave

Hapu – Indigenous Maori family

THL – Tourism Holdings

Adventure Caves

BWR – Blackwater Rafting

WA – Waitomo Adventures

SB – Spellbound

Support Activities

Jun – Junos

Rose – Roselands

Mus – Museum

Wdn – Woodlyns

T10 – Top 10 holiday park

CL – Cavellands general store

GL – Waitomo guest lodge

External Organisations

ATC – Adventure Tourism Council

DOC – Department of Conservation

EW – Environment Waikato (regulatory body)

NIWA – National Institute of Water and Air

NZOIA – New Zealand Outdoor Instructors Association

NZQA – New Zealand Qualifications Authority

SFRITO – Sport Fitness Recreation Industry Training Organisation

TNZ – Tourism New Zealand

UoA – University of Auckland

WDC – Waitomo District Council

Figure 1: Structural Arrangement in Waitomo Caves Tourism Destination, 2007.

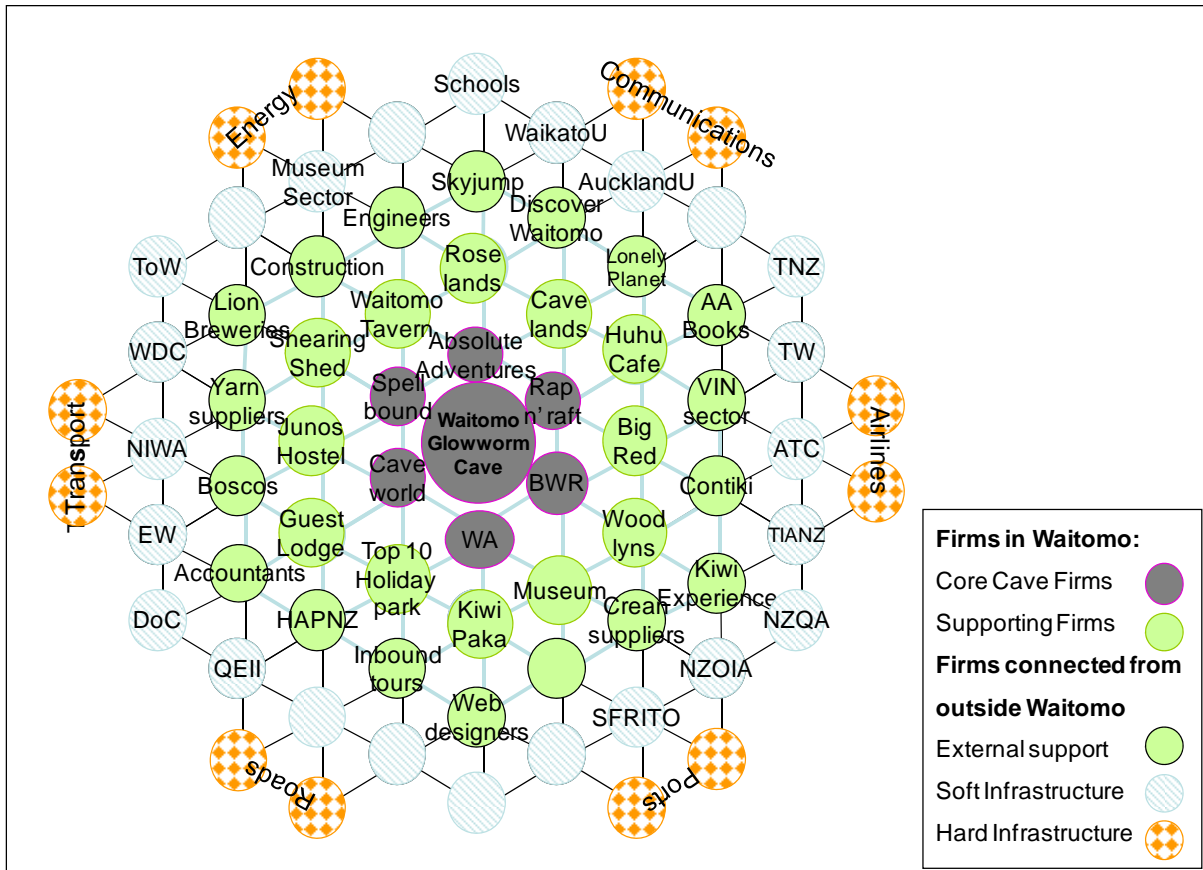


Figure 2: Waitomo Landcare Group

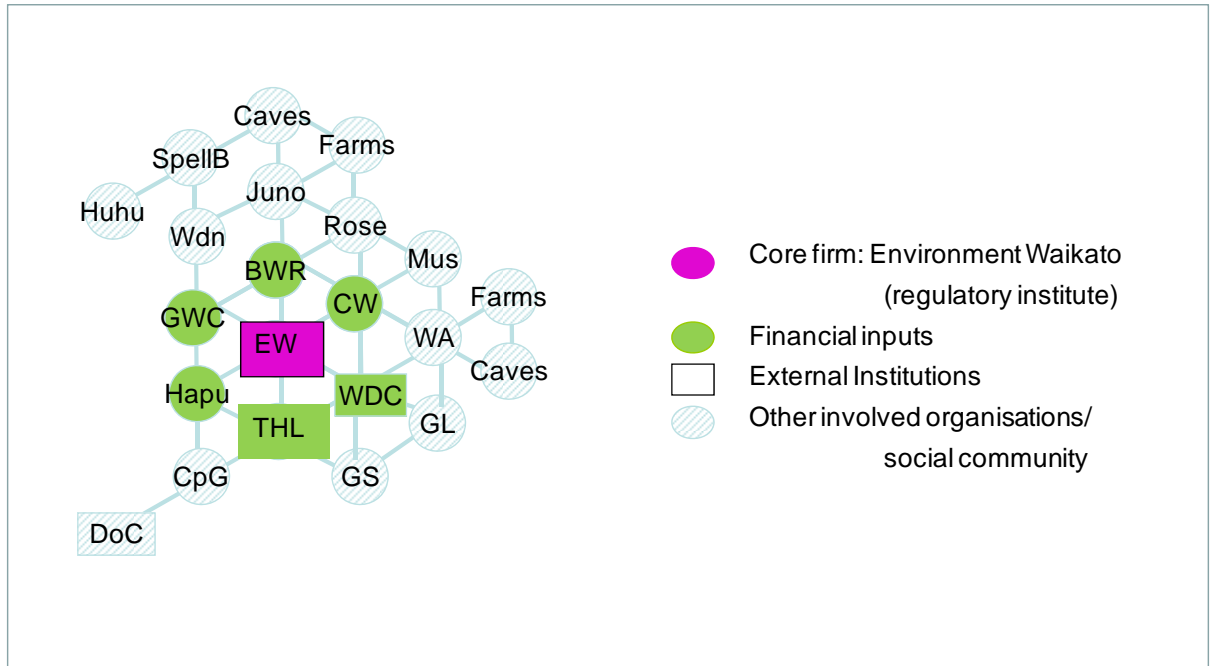


Figure 3: Adventure Risk Management

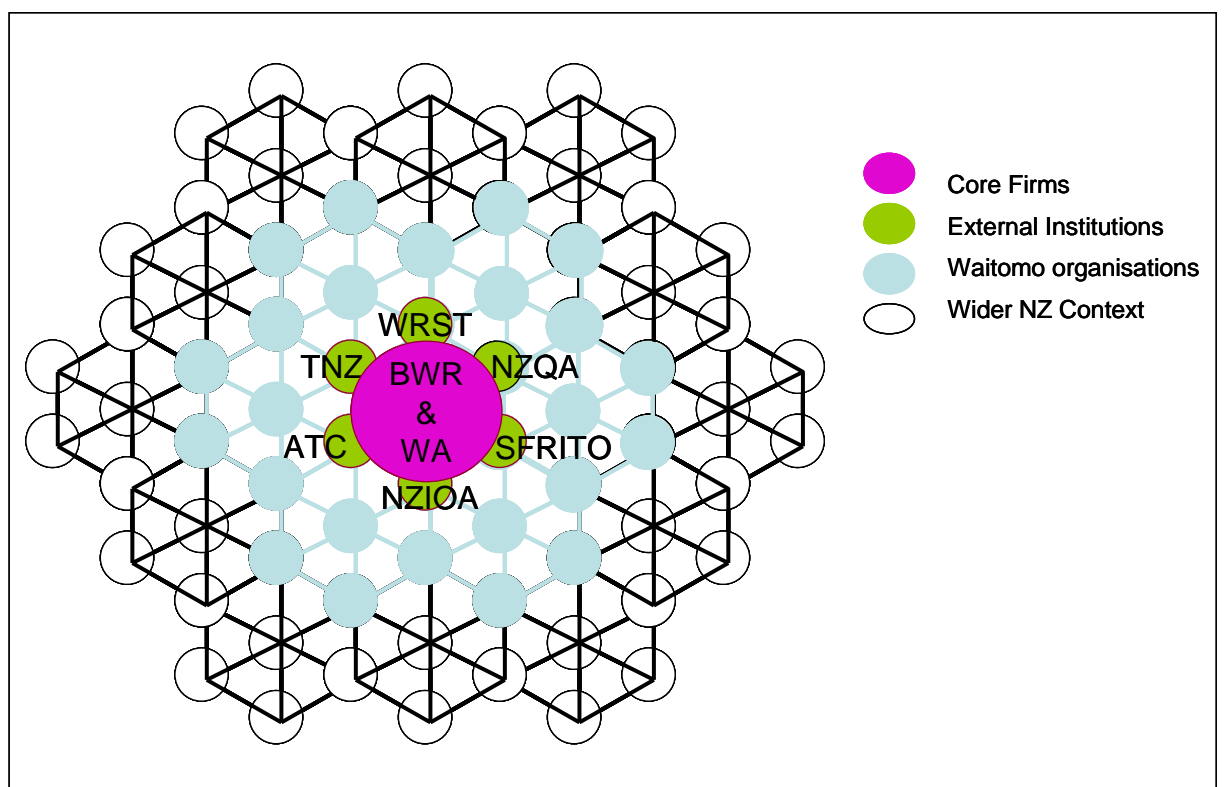


Figure 4: Underground Karst Monitoring

