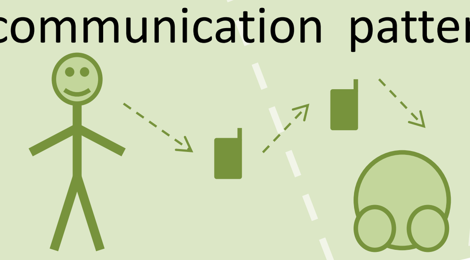
Biodiversity as a security approach in ad hoc networks

1. Research Objective

Maintaining security within computer networks is a continuing problem. In scenarios such as digital virus epidemics few operating systems and protocols can exacerbate the problem. Ecology research has found that undesirable disturbances to an ecosystem, such as the spread of viruses, can be reduced by increasing biodiversity. This research explores the effects of biodiversity as a security approach in ad hoc computer networks.

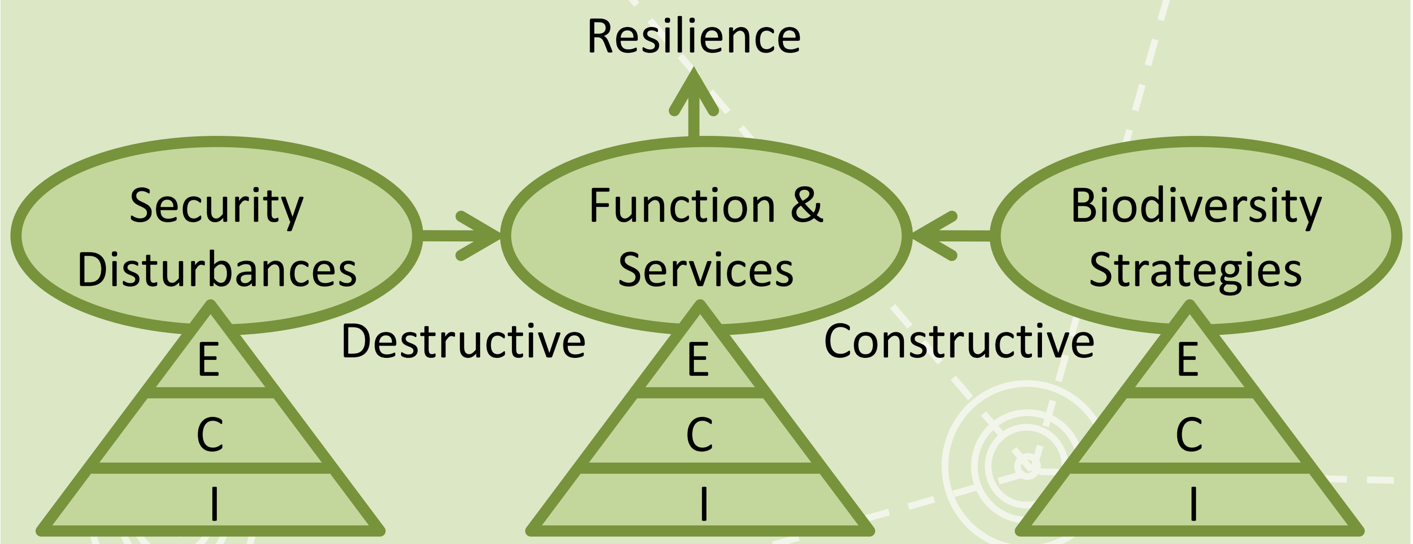
2. Ad Hoc Networks

An ad hoc network is characterised by devices connected in an arbitrary manner to form a network without a central controller. Messages are passed around the network in a series of hops. Ad hoc networks of the future are likely to interconnect applications such as home robots, wearable computers, and sensor networks. There are similarities between ad hoc networks and natural communities due to their movement and short range communication patterns making them a good candidate for studying the effects of biodiversity as a security mechanism.



3. The Biodiversity Benefit

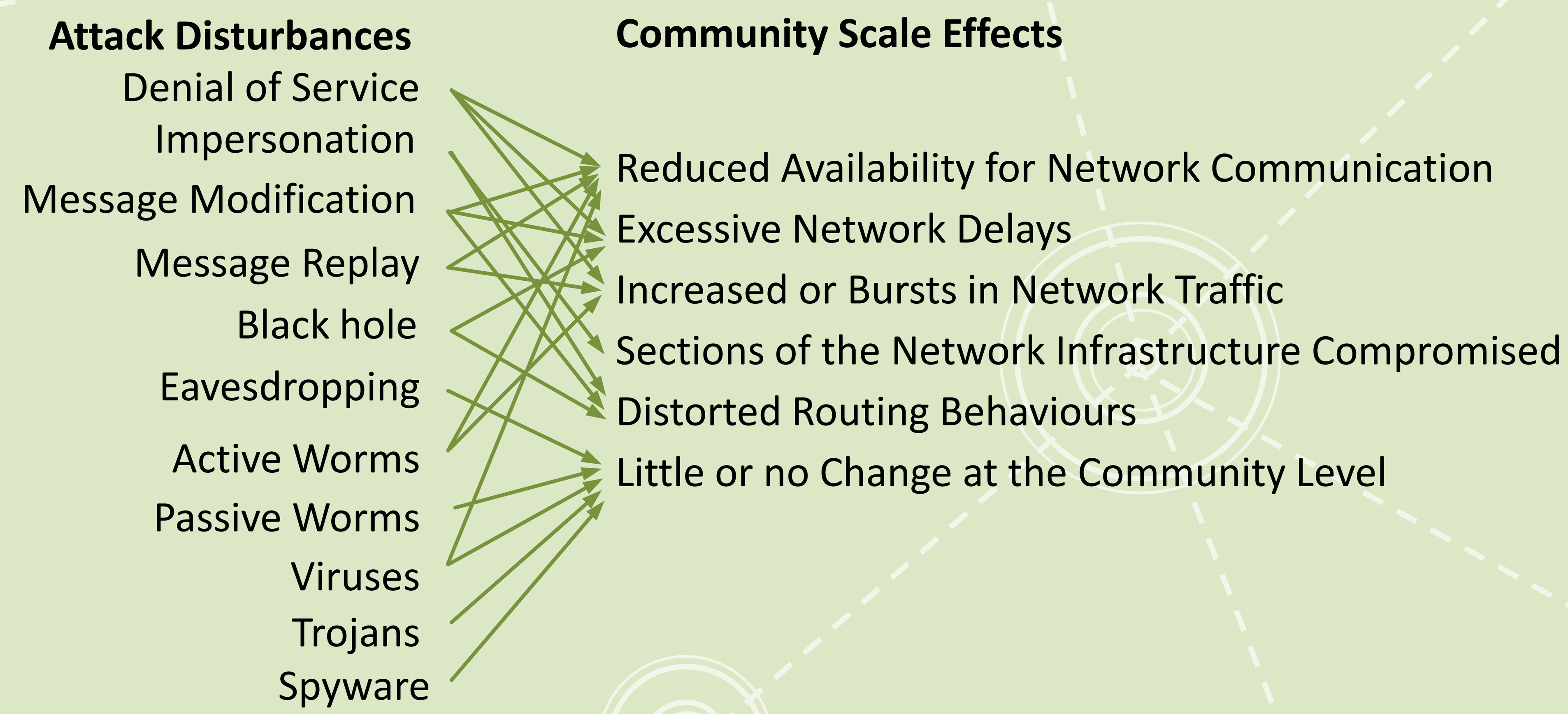
Ecology research has found that biodiversity promotes resistance to disturbances against the functioning of the ecosystem. In an ad hoc network environment security attacks can create destructive disturbances at the individual (I), community (C) or the ecosystem (E) scale affecting the functioning of the services provided by the network.



By applying biodiversity strategies at different scales, it is hypothesised that the destructive effects from security attacks can be tolerated to maintain ecosystem function.

4. Security Attack Disturbances

Common security attack disturbances causing effects at the community scale are shown here where network behaviours are affected.



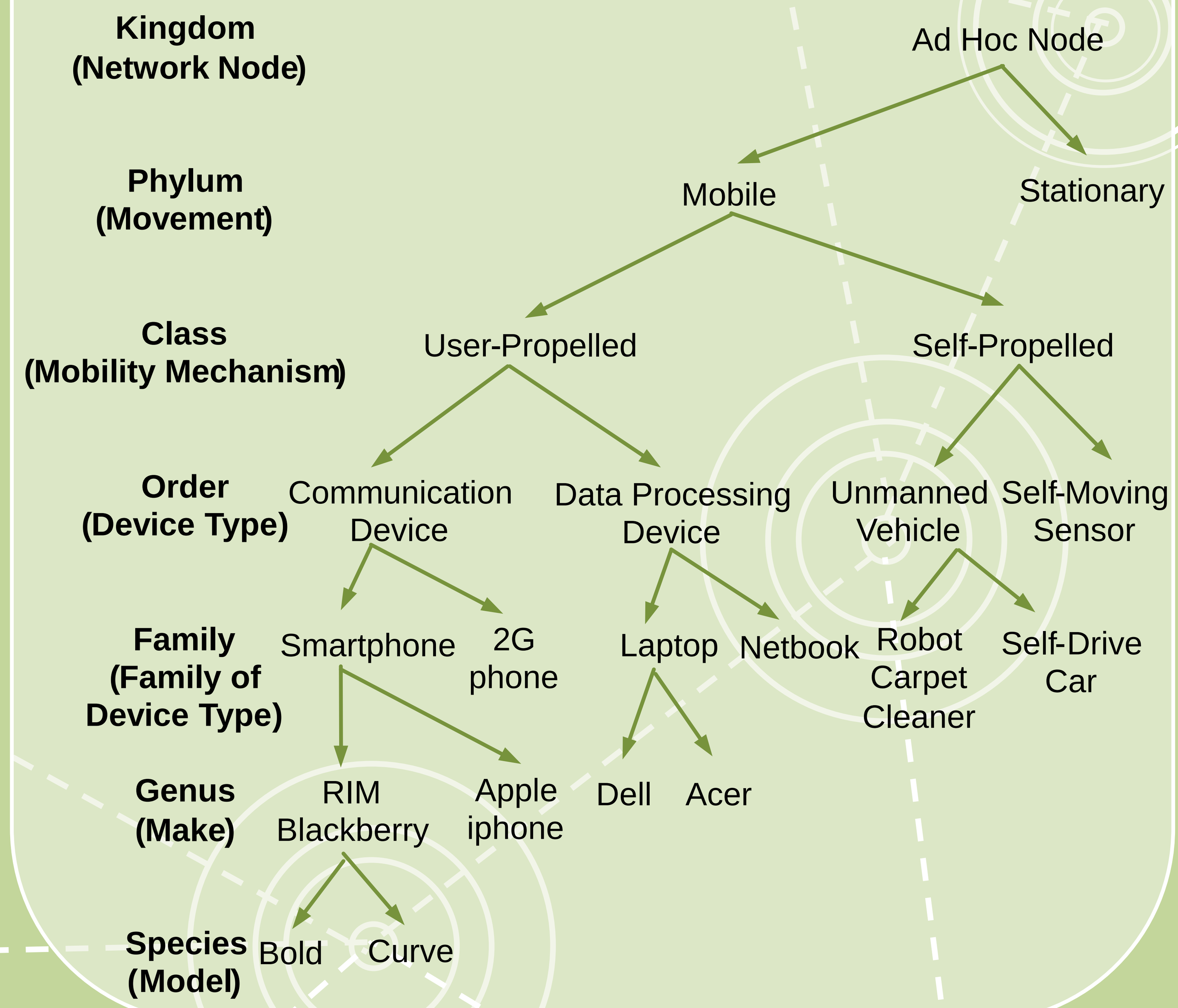
5. Three Scale Biodiversity Strategy and Classification System

Measuring and applying biodiversity strategies within an ad hoc network ecosystem requires classification and measurements at different scales.

Biodiversity Scales	Classification of ad hoc system	Biodiversity Measurements	Biodiversity Strategies
Large scale: (Ecosystem) Ecological Diversity	Classification of ad hoc network application environment Classification of services provided	Diversity between clusters of a large network or networks, between application environments or ecosystem services. Diversity changes over time	Environmental & habitat changes Biodiversity belts around homogeneous communities Increase resources available Provide incentives and benefit sharing schemes
Medium scale: (Community) Species & Functional Diversity	Taxonomy classification of ad hoc node types according to device product lines Functional classification of ad hoc node types according to similarities in their processes	Quantification of different ad hoc node types, their distribution and topology	Evolution & natural selection Distributed complementary species attributes Complementary functional groups Introduce predators, competitors, or pathogens Change the density of certain species Introduce varieties of a single species Introduce a sacrificial species Introduce a species that attracts beneficials Employ species rotation or intermixing Avoid hosts with similar vulnerabilities Replace species with more resistant variety
Small scale: (Individual) Genetic Diversity	Structural classification of software & hardware composition Behavioural classification of traits & characteristics	Detailed differences between nodes	Breeding Genetic modification Sterilisation Individual migration Birth Death

6. Community Scale Species Taxonomy

At the community scale one method of classification of ad hoc nodes is by a taxonomy system, similar to how species are classified.



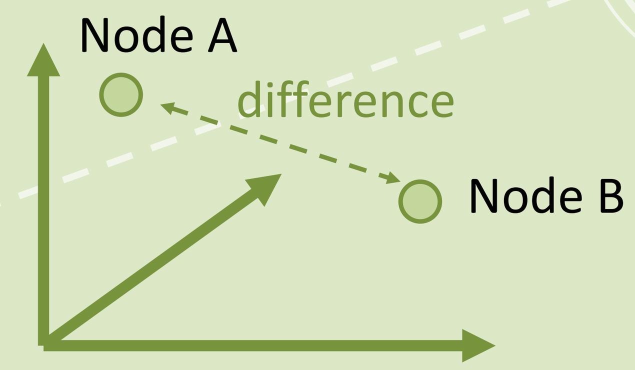
7. Individual Scale Genotype & Phenotype

At the individual scale where genetic diversity is measured genotype classification can be used to classify differences in software and hardware composition. A binary vector can be used to identify the presence (1) or absence (0) of a particular software or hardware component (x1-x9).

x1	x2	x3	x4	x5	x6	x7	x8	x9
0	1	1	1	0	0	1	0	1

Alternatively phenotype classification can be used to classify differences in the traits and characteristics of each node such as the communication frequency or migration rate. Each characteristic can be represented as a dimension with a scale representing the strength, so that each node will be a point in the vector space.

Two nodes with three characteristic dimensions.



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