A Non-Recursive Mathematical Implementation of the Probability Tree Diagram: Part I

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Introduction

This project, a collaborative process between Applied Research in Environmental Sciences (ARIES) and Elizabeth City State University (ECSU), and CREATE's Working Together for A Safer Tomorrow program, introduces and applies a user friendly model to assist local, state, and tribal entities to work together to identify evacuation routes. Consider a scenario where there are seven evacuation routes from a city Alpha to a city Beta, according to basic Combinatorics the total number of ways to exit Alpha are 5,040 (7-factorial). This is potentially a nightmare situation from disaster planning, because it is relatively impractical to enumerate the entire evacuation possibilities or combinations by hand or with the aid of a probability tree diagram. However, after thorough data analyses and research using Combinatorics it has been determined that the first part of two sets of formulae which enumerate the permutations of a given set of size n, repetition is allowed. In other words, this research introduces a non-recursive mathematical implementation of the probability tree diagram.

Progress

Proposed by students in July 2010, this project implemented a non-recursive probability model against a hypothetical scenario requiring evacuation from city Alpha to City Beta. A computer program to demonstrate a subset of the capabilities was written and a model tested.

Preliminary results indicate real time applicability and enhanced levels of predictive accuracy for use in quick time evacuations such as tsunamis, hurricanes and fires.

Mathematical Model of Evacuation from City Alpha to City Beta with 3×3×3 possibilities in an Ideal Scenario

For Simplicity, let X=City Alpha, Y=City Beta

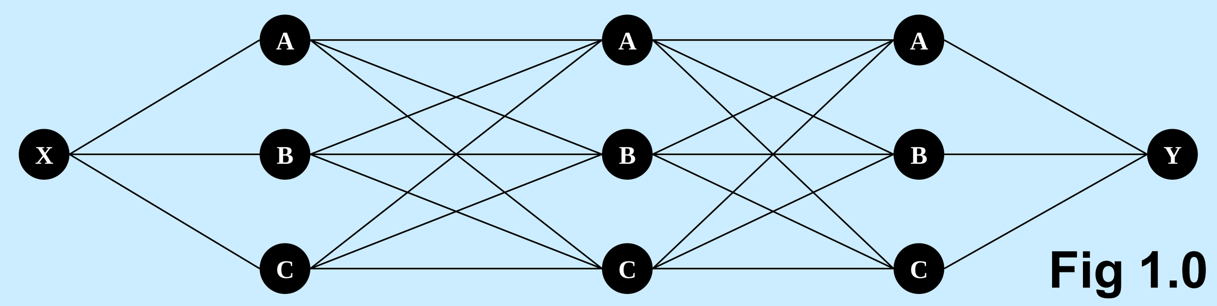

Fig 1.0

Methodology

Since there are 3 possibilities, total number of combination is 3×3×3=27. Let us use the formulae to obtain the permutation when *i=3*.
Assume that U={A,B,C}. *A=65, n=3. Since 3%3=0, f(i)=f(3)=3/3-1=0*

$$g_1(i) = g_1(3) = A + i - nf(i) - 1 = 65 + 3 - 3(0) - 1 = 67 = C$$

$$g_2(3) = A + f(3) = 65 + 0 = A$$

$$g_3(3) = A$$

The pattern generated is A A C. This can be translated from the abstract pattern: A A C into a typical route in the real world: Site1 Point1 Place3

C++Source Code Blocks and Output for 27 possibilities

```
long long F( long long n )
{
        if( n%s == 0 )
                return n/s - 1;
        else
                return n/s;
}
int g1( long long n )
{
        return A + (n-s*F(n)) -1;
}
int g2( long long n )
{
        if( F(n)<s )
                return A + F(n);
        else
                return A + (F(n)%s);
}
int g3( long long n )
{
        if( F(n)<s )
                return A;
        else if( F(n)>(s*s) )
                return A + (F(n)/s-s)%s;
        else if( F(n)>=s )
                return A + (F(n)/s);
}
```

1	XAAAY
2	XAABY
3	XAACY
4	XABAY
5	XABBY
6	XABCY
7	XACAY
8	XACBY
9	XACCY
10	XBAAY
11	XBABY
12	XBACY
13	XBBAY
14	XBBBY
15	XBBCY
16	XBCAY
17	XBCBY
18	XBCCY
19	XCAAY
20	XCABY
21	XCACY
22	XCBAY
23	XCBBY
24	XCBCY
25	XCCAY
26	XCCBY
27	XCCCY

Mathematical Model

The frequency:

$$f(i) = \begin{cases} \frac{i}{n} - 1 & i\%n = 0 \\ \frac{i}{n} & i\%n \neq 0 \end{cases}$$

The first term function:

$$g_1(i) = A + i - nf(i) - 1$$

The second term function:

$$g_2(i) = \begin{cases} A + f(i) & f(i) < n \\ A + f(i)\%n & f(i) \geq n \end{cases}$$

The third term function:

$$g_3(i) = \begin{cases} A & f(i) < n \\ A + \frac{f(i)}{n} & n \leq f(i) < n^2 \\ A + \left(\frac{f(i)}{n} - n\right)\%s & f(i) \geq n^2 \end{cases}$$

Fig 1.1

Potential End User	Application Examples
Federal, State, Local, Tribal Governments	✓ Resource Allocation, Transportation Flow ✓ Geographic Distribution of Resources ✓ Disaster and Terror Event Planning ✓ MOU and MOA Development ✓ State, Local, and Tribal Integration
Academia	✓ Student and Faculty Research ✓ Campus Disaster Preparation ✓ MOU and MOA Development
Corporations	✓ Asset Protection ✓ Operational Continuity ✓ Infrastructure Support Strengthening
Hospitals	✓ Surge Capacity Preparation ✓ Service Area Identification ✓ Service Area Agreements ✓ Regional Response Planning
Indian Reservations	✓ Casino and Gaming Facility Asset Protection ✓ MOU and MOA Development ✓ Historical Documents and Artifact Protection ✓ Regional Response Cooperative Planning
Air Terminals	✓ Casino and Gaming Facility Asset Protection ✓ MOU and MOA Development ✓ Diversion Landing Capabilities: Equipment, Personnel, Grounding, Refueling
Prisons	✓ Human Resource Allocation, i.e. Staffing ✓ Security Enhancement Procedures ✓ Holding Area for Post Event Looters

Table 2.1

Conclusion

The possible applications of this novel formulae are numerous spanning across Mathematics, Computer Science, Cryptography, and Biology. However, this present process can be utilized by resource allocators at the local, tribal, state, and national levels to develop cooperative approaches that utilize shared human and material resources to maximize response capabilities and reduce the economic impact of natural disaster and terror events. The product can be used to enhance prompt and efficient regionally coordinated activities via an integrated tribal, state, and local governmental effort using resources cooperatively managed in accordance with an existing framework. This integrated effort among state, local, and tribal governments could save millions of taxpayer dollars.

Preliminary Findings & Future Plans

Preliminary Findings: The computational complexity of the formulae for a given scenario is constant even in the worst case of *i*. This is significant because a program can be designed and run on a standard home computer instead of a supercomputer.

Future Plans: The formulae are presently undergoing test runs and will target selected areas in Southern Florida in the near future.

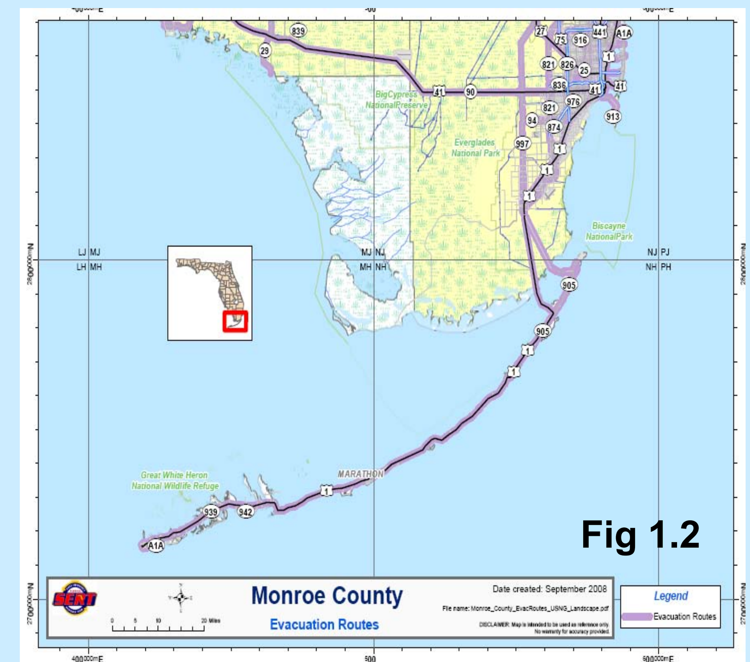

Fig 1.2

Fig 1.3

Selected References

1.Knuth, D. E. (2005). "Generating All Tuples and Permutations". The Art of Computer Programming. 4, Fascicle 2. Addison-Wesley. pp. 1–26. ISBN 0-201-85393-0.
2. . Dr. JamiiruLuttamaguzi, Elizabeth City State University

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