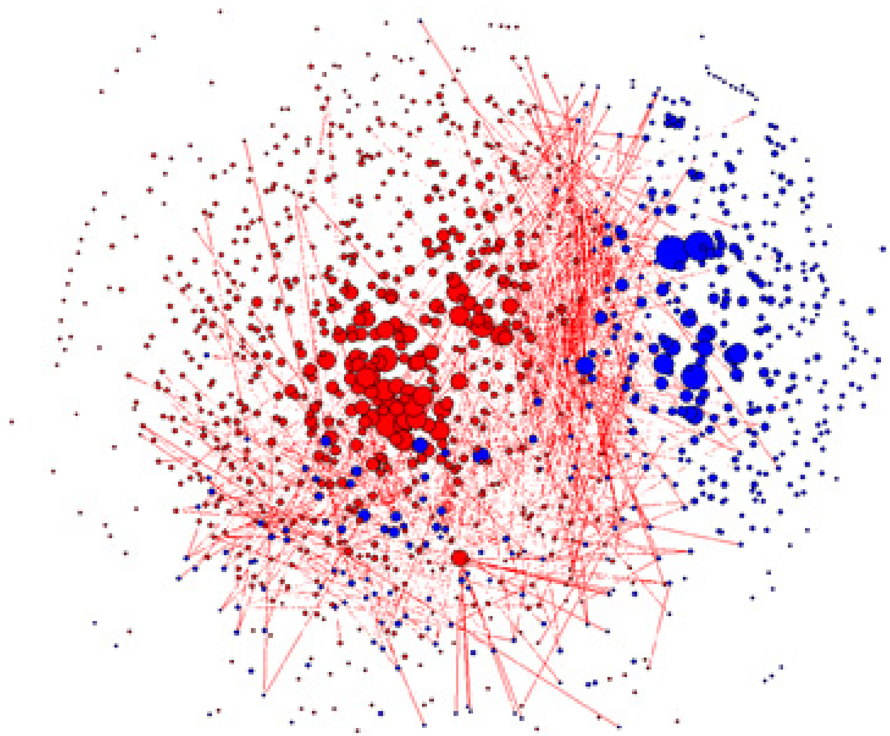
The Economics Of Networks And Cybersecurity



Rod Beckström

Director

National Cybersecurity Center

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Economics of Networks

Value of network to one user
Total value of a network
Security economics
Security risk management
Hacker economics
Economics of deterrence
Supply chain incentives
Economics of Internet protocols (architecture)
Economics of outages
Economics of resiliency (correlation of losses)

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Economics of Networks

Fundamental Questions

What is the value of a network?

How much should be spent to defend it?

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Definition of Relationship to Network

A user can have an implicit or explicit contractual relationship with a network and perform transactions through it.
The presence of a network can impact the price, value and nature of transactions.
Some
transactions may only be available only on that network.

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Economics of Networks

Definition of a User

A user can be any entity that contracts for transactions, whether an individual, company, non-profit organization, government or any other party.

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Valuing Networks

Previous models focused on the number of nodes or users (Metcalfe's Law, Reed's Law), or on the architecture or structure of the network.

This focus was misplaced.

Economics of Networks

New Model: Beckstrom's Law

The value of a network equals the net value added to each user's transactions conducted through that network, summed for all users.

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New Network Valuation Model
Alternative but Equivalent Description

The value of a network equals the value added to all transactions conducted on that network, valued from the standpoint of each user.

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New Network Model

Value of a Network to One User

$$V = \Sigma B - \Sigma C$$

Where:

V	= value of network to one user
B	= the benefit value of all transactions
C	= the cost of all transactions

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Economics of Networks

First, we need to determine the value a network like the Internet adds to a single user such as you.

Then, if we do the same for all users and sum it up, we have the total network value.

Let's first calculate the value of one transaction, that of purchasing a book online versus at the bookstore.

Book Purchase Example

You decide to buy a book online instead of at a bookstore, to save money. How much value does the network add?

If it costs $26 to buy the book in a store or $16 to buy it over the Internet, including shipping, the net value is $10.

$$V = B - C$$

$$V = \$26 - \$16$$

$$V = \$10$$

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One User Example

If you then tallied up all of the books and other products a user purchased over the internet, and the Benefit value of free searches, research, reading, entertainment and phone calls, less all associated costs of network usage and transactions, you then have a composite net value V to that Individual over any time period, for example, one year.

The same approach can be used to value any network for that user.

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Benefits (B) are Bounded

The benefit value is bounded with a lower and an upper limit. It should be higher than the Cost and it should be equal or less than the Cost of obtaining the product through another means, with identical quality of service. In a paired transaction like buying a book, where you deliver money and receive a book, the Benefit is assumed to be higher than the Cost. You would not pay more for a book than you value it. On the upper limit, the Benefit should not be greater than the all-in cost of purchasing an identical product or service from another provider. So if instead of buying a book online, you could pick it up from the bookstore below your office for $26 (including your time), then that is the maximum Benefit, even if you would pay $100 for it if you had to.

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Benefits (B) are Bounded

$$C < B < LAC$$

Where:

C	= Cost of a transaction
B	= the benefit value of a transactions
LAC	= the Lowest Alternative Cost of a transaction through another network

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Economics of Networks

Benefits (B) are Bounded

Because the Benefits are bounded, and the value to transactions is computed for each user from their unique perspective, it is possible to sum the value to all users.

In the book example, the user benefits $10. The online bookseller can still make a $1 profit, which is their net value from the transaction as well.

The shipper may make 50 cents on the transactions.   These net benefits gained by other parties can be summed up for the network, and there is no double counting.

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Costs (C)

Costs include the cost of joining or maintaining access to a network, such as paying for Internet access charges, and all costs of doing transactions over that network, including labor time, electricity, the costs of products, and any other costs. Most costs (except time) can be fairly straight forward to track and account for.

The Internet is interesting as a network, because once access is paid for, there are many services which are offered for free, such as Skype calls, Wikipedia information, search services, etc. These provides significant Benefits (B).

New Network Model

Network Value is Summation of Value to All Users

$$\Sigma V = \Sigma B - \Sigma C$$

Where:

ΣV = value to all users of a network
B = the benefit value of all transactions
C = the cost of all transactions

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New Network Model

Beckstrom's Law for Valuing Networks

$$\sum_{i=1}^{n} V_{i,j} = \sum_{k=1}^{n} \frac{B_{i,k}}{(1+r)^{t_k}} - \sum_{l=1}^{n} \frac{C_{i,l}}{(1+r)^{t_l}}$$

Where:

$\Sigma V_{i,j}$ = value of a network $_j$ to all users
$V_{i,j}$ = net present value of all transactions to user$_i$
with respect to network $_{j,}$ over any time period
$_j$ = identifies one network
$_i$ = one user of the network
$B_{i,k}$ = the benefit value of transaction $_k$ to individual $_i$
$C_{i,l}$ = the cost of transaction $_l$ to individual $_i$
r_k and r_l = the discount rate of interest to the time of transaction $_k$ or l
t_k or t_l = the elapsed time in years to transaction $_k$ or $_l$

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The “Network Effect”

This effect is much discussed but poorly defined. Generally refers to increase in value of network as size increases.
Metcalfe’s Law is sometimes referred to.

Using the New Network Valuation Model, the value of the network increases as more users join, bringing more transactions to the network.

The more potential transactions a network has to offer, the more users will be attracted to it.

The “Network Effect”

The more users are attracted, the more valuable the network becomes, and a virtuous cycle develops.

Other networks stand to lose as one gains.

The value is locked in, if there are no comparable networks, or there are significant barriers and costs to switching.

The “Network Effect”

As the number of users doing transactions grows, the value
Of a network tends to grow (unless the increase in number of users has some offsetting negative effect on the network, such as Less trust). For networks that increase in value with size:

$$\sum_{i=1}^{n+1} V_{i,j} > \sum_{i=1}^{n} V_{i,j}$$

Some examples of networks that decrease in value with increase in size are support groups and exclusive clubs.

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The “Network Effect”

More broadly, as more users move to the Internet, it is replacing almost all other networks, because it adds Continues to add more value to most users:

$$V_{Internet} > V_{Proprietary}$$

Where:

$V_{Proprietary}$ = Value of a proprietary network

$V_{Internet}$ = Value of Internet network

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The “Network Effect”

You need to buy a flight, and can call around to airlines (phone) or use a travel search engine on the Internet. You might rank the value of services as follows:

$$V_{Internet} > V_{Phone}$$

Where:

$V_{Internet}$ = Transaction Value of Internet Network

V_{Phone} = Transaction Value of Travel Agent Service

“Inverse Network Effect”

Some networks decrease in value when they exceed a certain size. Whether a corporate board, a support group, or an exclusive club, Some networks decrease in value as size increases, beyond some point. Sometimes less is more. Beyond their optimal size, These networks exhibit the following behavior:

$$\sum_{i=1}^{n} V_{i,j} > \sum_{i=1}^{n+1} V_{i,j}$$

Why? In support groups for example, there is only so much time for each person to speak. More people, less speaking for each, plus the affinity may decrease.

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Economics of Security

Basic Model

$$V = B - C$$

Sigmas (*Σ's)* ommited but assumed henceforward.

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Economics of Security

Basic Model

$$V = B - C$$

Security Model

$$V = B - C' - SI - L$$

Where:

SI = Security Investments

L = Losses

C' = C – SI – L (all costs except SI & L)

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Economics of Security

The Fundamental Security Risk Management Function

Minimize Security Costs = SI + L

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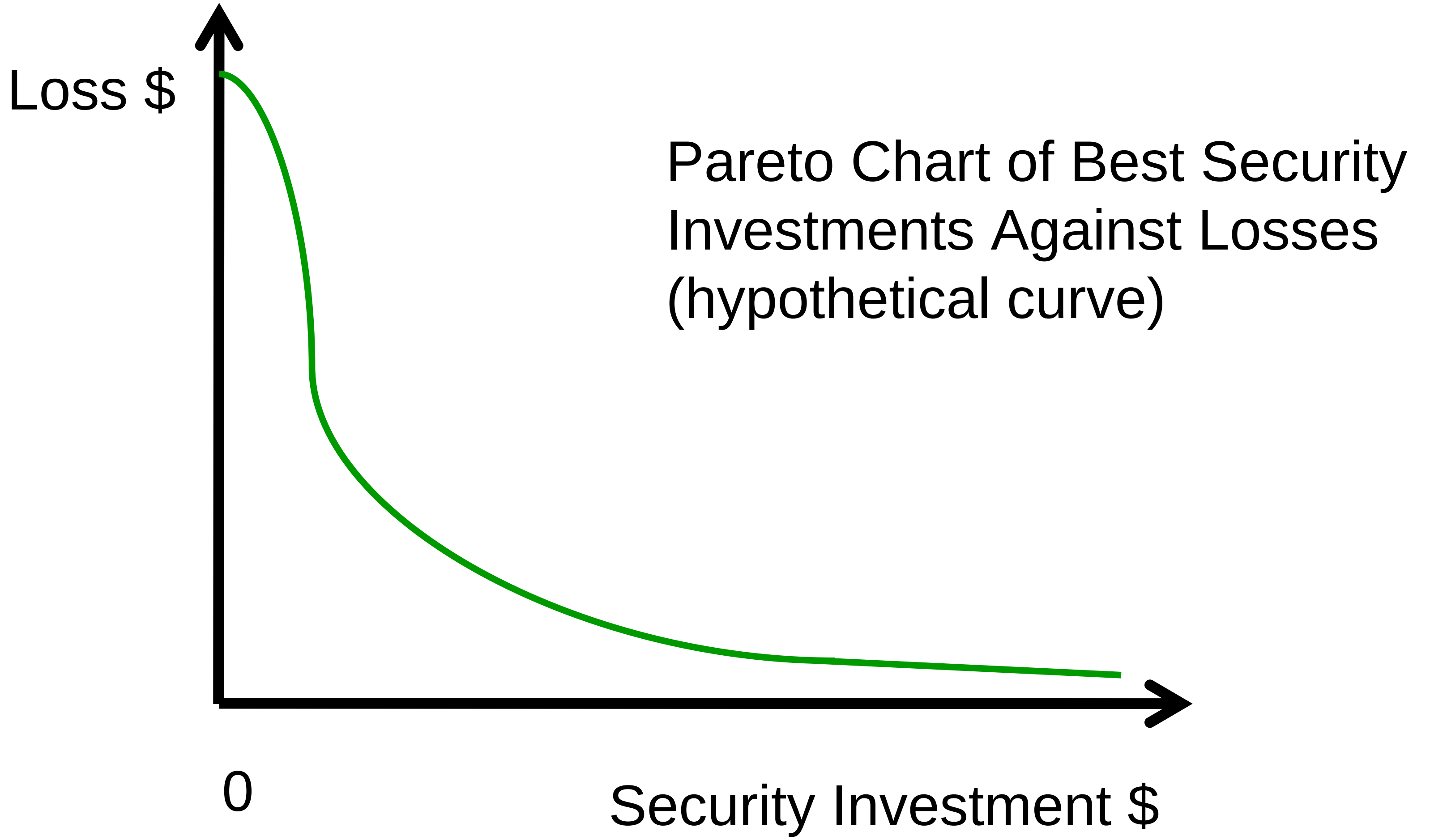
Economics of Security



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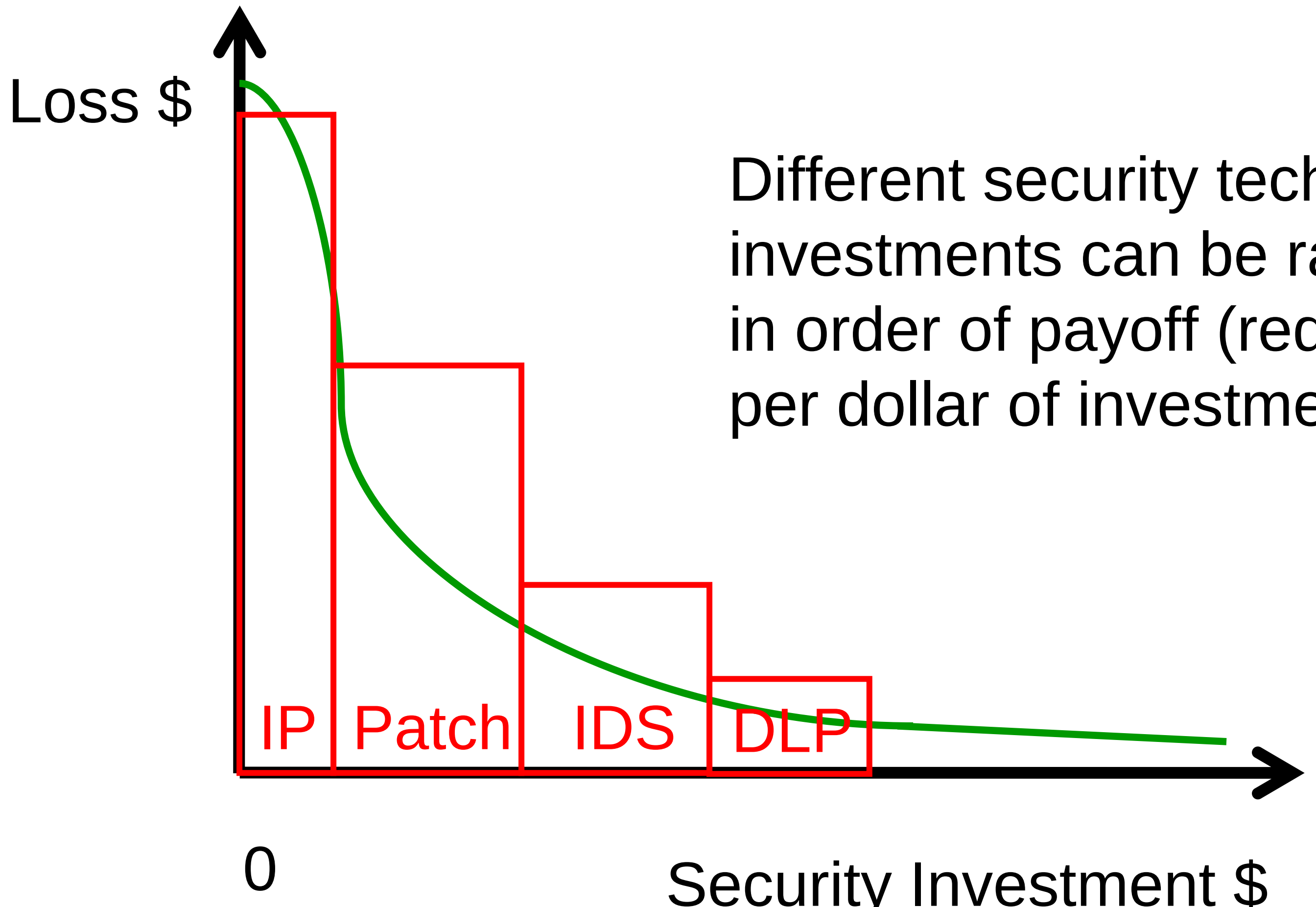
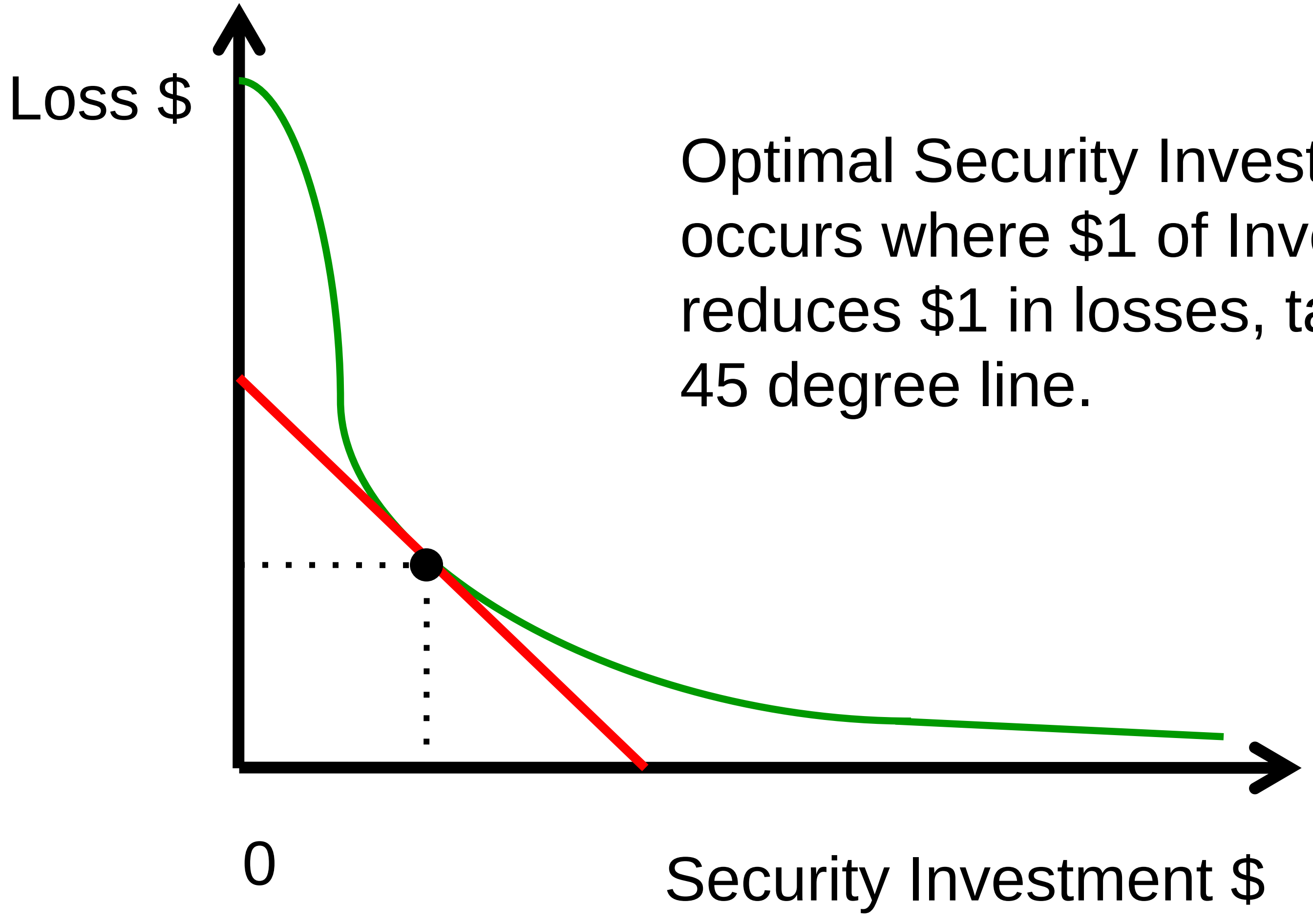
Economics of Security



Different security technology investments can be ranked in order of payoff (reduced losses per dollar of investment).

Economics of Security



Optimal Security Investment occurs where $1 of Investment reduces $1 in losses, tangential to 45 degree line.

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Economics of deterrence

Minimize the Hacker's Gain

$$Minimize\ V = B\downarrow - C'\uparrow - SI\uparrow - L\uparrow$$

For example, by seeking to reduce their Benefit or take.
Increase their operating costs (making stealing more difficult).
Force them to invest more in their own Security Investments (making it harder for them not to get caught).
Increase their losses by improving enforcement and increasing Penalties and imprisonment, for example.

Hacker Economics

Your Loss

$$V = B - C' - SI - L$$

Hacker Economics

Your Loss

$$V = B - C' - SI - L$$

Is the Hacker's Gain

$$V = B - \underline{C' - SI - L}$$

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Hacker Economics

Your Loss

$$V = B - C' - SI - L$$

Is the Hacker's Gain

$$V = B - \underline{C' - SI - L}$$

Criminal hacking for financial gain is worse than a zero sum game. It creates no value and adds great costs to the system.

Economics of deterrence

Minimize the Hacker's Gain

$$Minimize\ V = B - C' - SI - L$$

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Economics of deterrence

Minimize the Hacker's Gain

$$\textit{Minimize } V = B\downarrow - C'\uparrow - SI\uparrow - L\uparrow$$

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Supply Chain Economics

Hackers Like High Benefit/Low Cost of Embedded Malcode

$$V = B - \uparrow C' - \downarrow SI - L$$

Supply Chain Policy Objective:
reduce malicious code in products

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Supply Chain Solution

1) Reward Good Guys

Pay large fees to Anyone who finds malicious code

$$V = \Sigma B \uparrow - \Sigma C' - \Sigma SI - \Sigma L$$

2) Punish Bad Guys

Levy large fines on companies with infected products

$$V = \Sigma B - \Sigma C' \uparrow - \Sigma SI - \Sigma L$$

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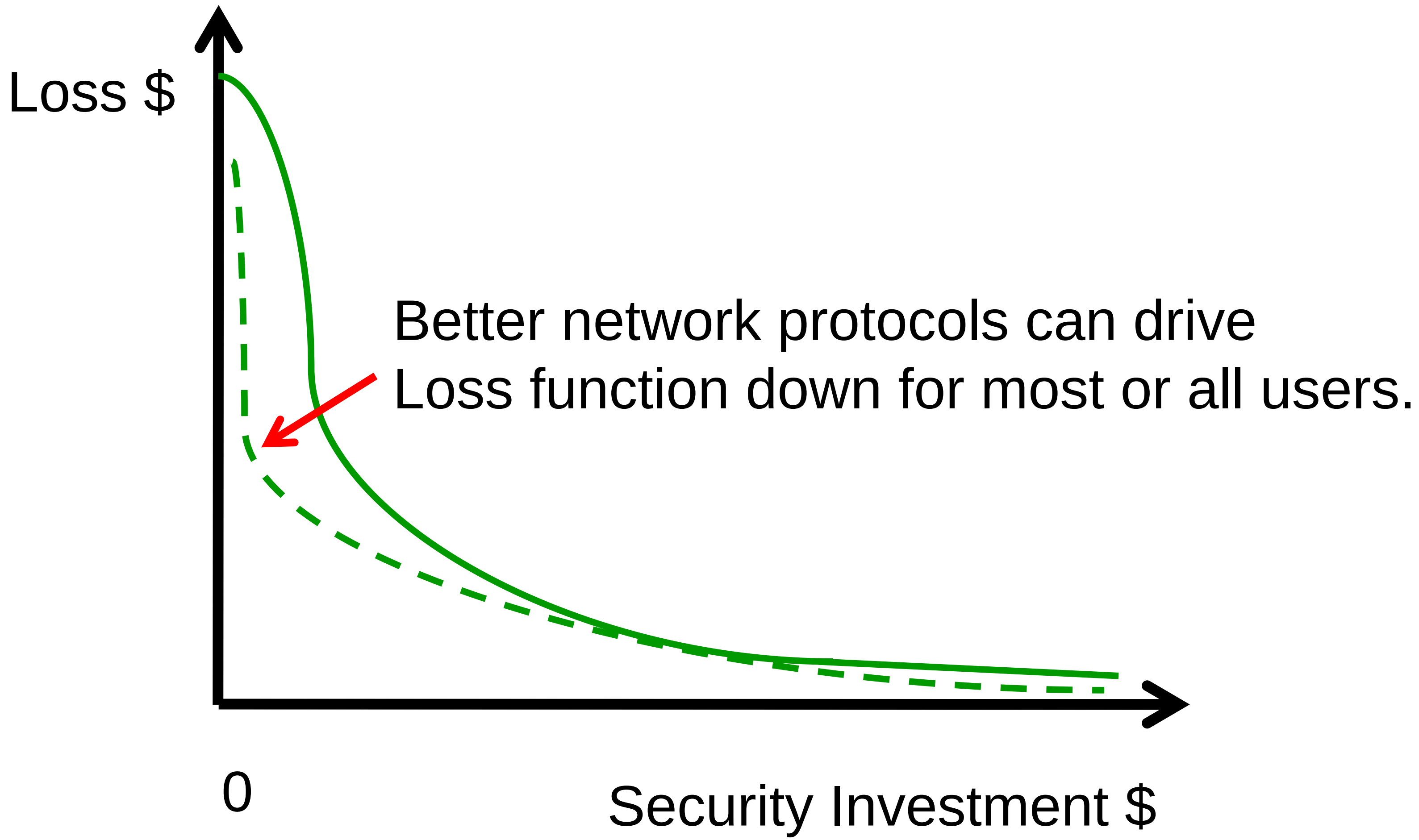
Economics of Protocols



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Protocol Investments

Enhance Internet Architecture

IPv6, DNS-SEC, BGP-SEC, SMTP

Protect Other Networks/Protocols

SMS/IP, POTS …

Economics of Outages

Security Model

$$V = B - C' - SI - L$$

If Network Shuts Down:

1) Normal operating loss goes to zero
2) Loss becomes lost V (Value of Network)

L = *Lost NPV*

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Impact of IP Outages

$$\sum_{i=1}^{n} (L_{IP,i}) = L_{IP,\ Ecommerce} + L_{IP,SMS} + L_{IP,Phone} + L_{IP,SCADA} \ldots$$

Where:

$L_{IP,i}$ = lost value of Internet Protocol (IP) services failing to activity i

i = a category economic activity

$L_{IP,Ecommerce}$ = Economic Loss of IP service failure to Ecommerce

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Impact of IP Outages

IP based economic activities spread…

- **as surely as an apple falls from a tree**
- **with the power of a tsunami**
- **the value of the Internet increases**
- **many or most activities become vulnerable**
- **all activities which are IP dependent, trend towards a correlation of losses of 1.0**
- **this is one of the greatest points of economic and security risk in the world**

Economics of Networks

Value of network to individuals
Total value of a network
Security economics
Security risk management
Hacker economics
Economics of deterrence
Supply chain incentives
Economics of Internet protocols (architecture)
Economics of outages
Economics of resiliency (correlation of losses)

The Model Can…

Be used to calculate or determine:

- **The value of a network**
- **How to optimize a company's security investments**
- **How to optimize a country's security investments**
- **Rigorously compare alternative security investments**
- **The economics of hacking**
- **The incredible leverage of supply chain hacking**
- **Incentivize discovering supply chain hacks**
- **Incentivize better supply chain testing**
- **The value of re-architecting the Internet**
- **Analyze internet business models**
- **Value of having a diversity of networks**
- **Value of having redundant protocols within a network**

Benefits of New Model

Highly granular (every transaction included)
Focuses on value to each party from their standpoint
Accurate
Simple
Network architecture independent
Scales from one user to one or all networks
Subsets of users can be analyzed
No double counting of benefits
Consistent with existing cost accounting methods
(e.g. amortizing costs over time)
Consistent with profit and loss accounting
Can be applied as foundation model for other network, security and policy problems (deterrence, outages, etc.)

Questions About Model

Is this a new universal model for network valuation? Why or why not?

Does it equally apply to off-line social networks (e.g. trade associations) as on-line networks?

Can it be used to value other relationships between individuals, or between creatures in nature?

Should it be called an Economic Model of Relationships instead of an Economic Model of Networks?

Possible Next Steps

Empirical work to estimate Benefits and Costs in various networks or for various companies, countries.

New derivatives of model can be developed to examine problems such as Net Neutrality and internet service pricing policies, and issues of privacy.

Economics Of Networks And Cybersecurity

Rod Beckstrom
Director
rod.beckstrom@dhs.gov

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