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Shannon, Hypergames and Information Warfare

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Defining Information Warfare

US DoD: *'Information Warfare is any action to Deny, Exploit, Corrupt or Destroy the enemy's information and its functions; protecting ourselves against those actions and exploiting our own military information functions'.*

- IW is defined as 'actions' which yield intended outcomes of 'denial', 'exploitation', 'corruption' and 'destruction' of an opponent's 'information'.

- The model does not provide a quantifiable basis or measure of 'information'.

- Borden (1999) and Kopp (2000) argue that Shannon (1948) provides a model to address this limitation. Shannon's 'channel capacity' model relates useful channel capacity to bandwidth and the ratio of available signal to noise.

Shannon's Model (1)
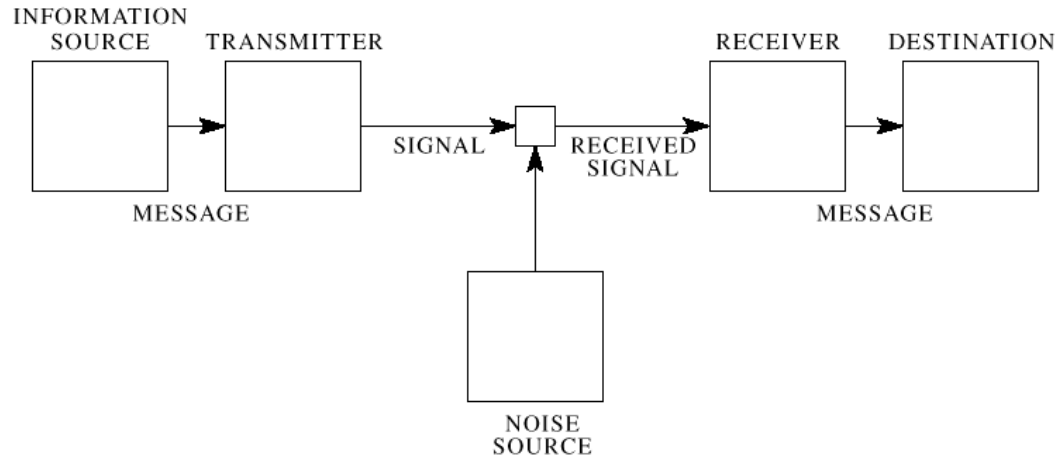
$$C = B.log_2(\frac{S}{N}) \tag{1}$$

Shannon's Model (2)

- Shannon's model defined in terms of a communication channel, with a 'source', 'destination', 'transmitter', 'receiver' and a 'noise source' which impairs the channel 'capacity', otherwise bounded by 'bandwidth' and 'signal'.

- Borden: 'IW is a battle for bandwidth (capacity)'.

- Shannon's model can be easily mapped on to the four 'canonical offensive Information Warfare strategies'.

  1. **Denial of Information.**
  2. **Deception and Mimicry.**
  3. **Disruption and Destruction.**
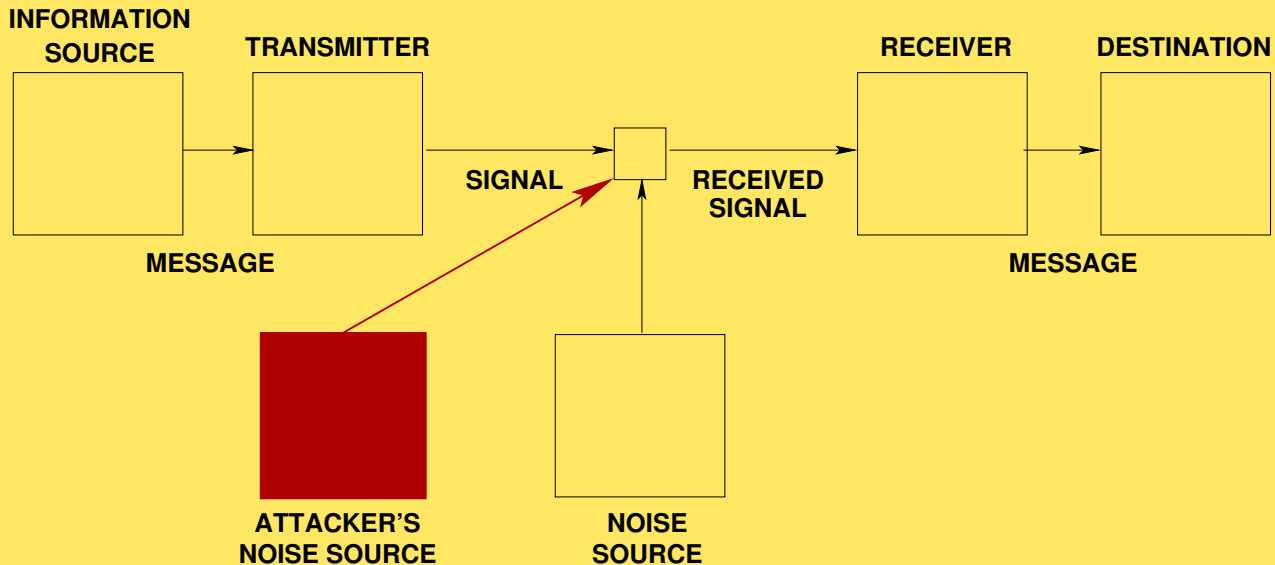 4. **SUBversion.**

Four Canonical IW Strategies

1. **Denial of Information / Degradation or Destruction (US DoD)**, i.e. concealment and camouflage, or stealth.

2. **Deception and Mimicry / Corruption (US DoD)**, i.e. the insertion of intentionally misleading information.

3. **Disruption and Destruction / Denial [1] (US DoD)**, i.e. the insertion of information which produces a dysfunction inside the opponent's system; alternately the outright destruction of the receiver subsystem.

4. **SUBversion / Denial [2] (US DoD)**, i.e. insertion of information which triggers a self destructive process in the opponent's target system; SUB at the simplest level amounts to the diversion of the thread of execution within a Turing machine.

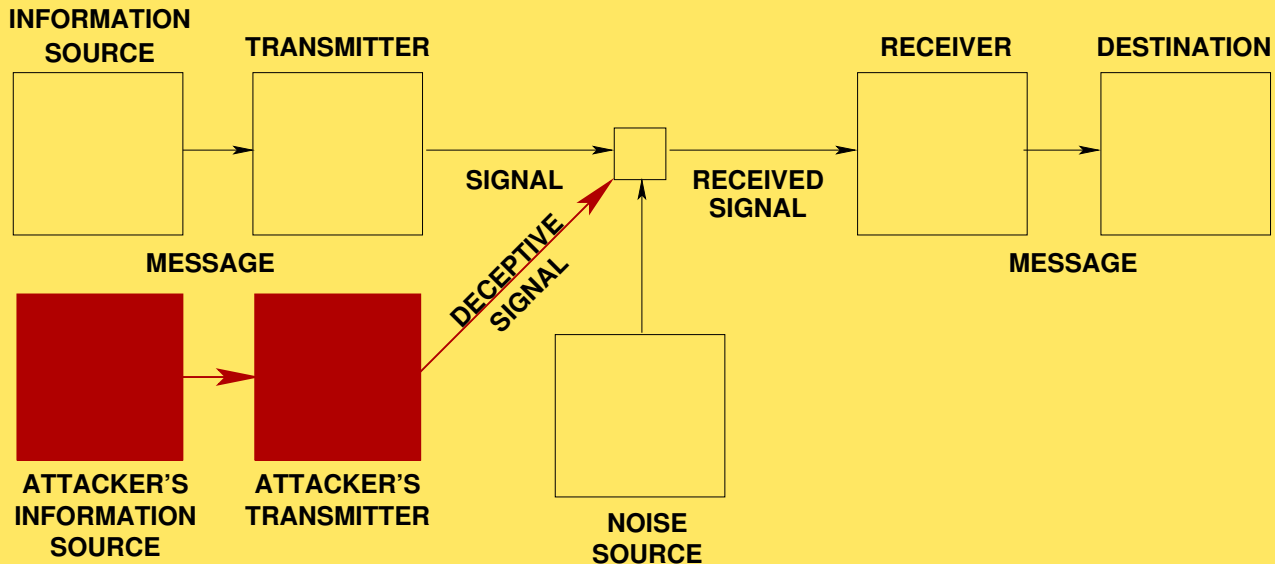# Model for DoI/Degradation Strategy

INFORMATION SOURCE · **TRANSMITTER** · **SIGNAL** · **RECEIVED SIGNAL** · **RECEIVER** · **DESTINATION** · **MESSAGE** · **ATTACKER'S NOISE SOURCE** · **NOISE SOURCE** · **MESSAGE**

1. DoI/Degradation Strategy

Model for D&M/Corruption Strategy

2. D&M/Corruption Strategy

Model for D&D/Denial (1) Strategy

INFORMATION SOURCE   TRANSMITTER   RECEIVER   DESTINATION

SIGNAL   RECEIVED SIGNAL

MESSAGE   MESSAGE

ATTACKER DISRUPTS OR DESTROYS RECEIVER

NOISE SOURCE
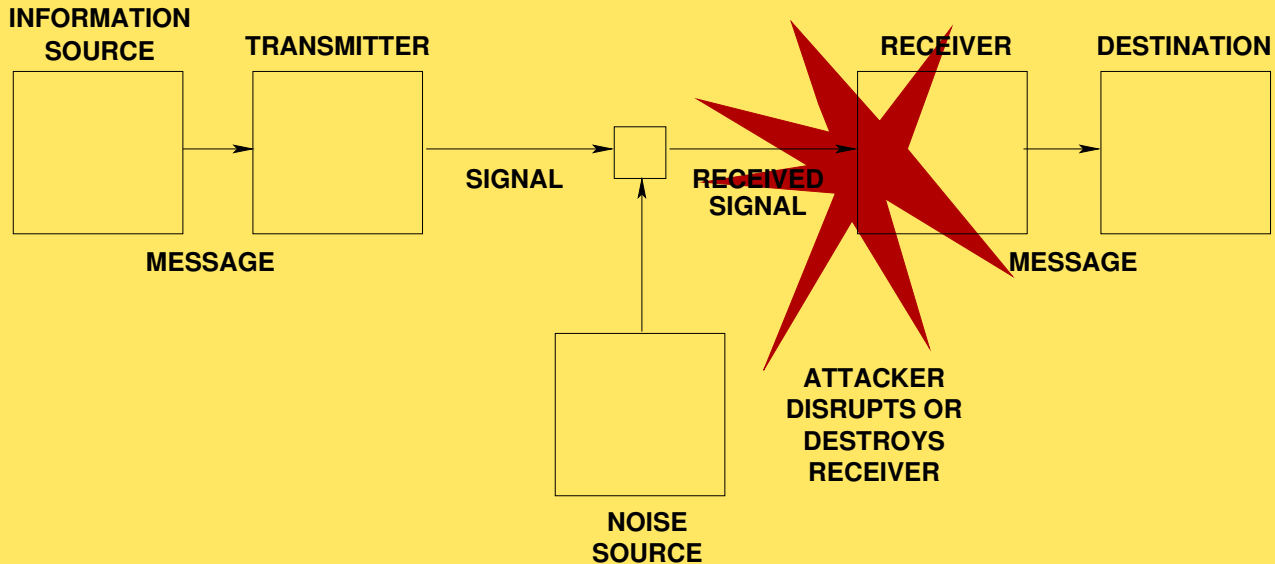
3. D&D/Denial [1] Strategy

Model for SUB/Denial (2) Strategy

INFORMATION SOURCE

TRANSMITTER

RECEIVER

DESTINATION

MESSAGE

SIGNAL

SUBVERSIVE SIGNAL

(A)

RECEIVED SIGNAL

MESSAGE

(B)

ATTACKER'S SUBVERSIVE INFORMATION SOURCE

ATTACKER'S TRANSMITTER

NOISE SOURCE

DESTRUCTIVE EFFECT IN VICTIM SYSTEM
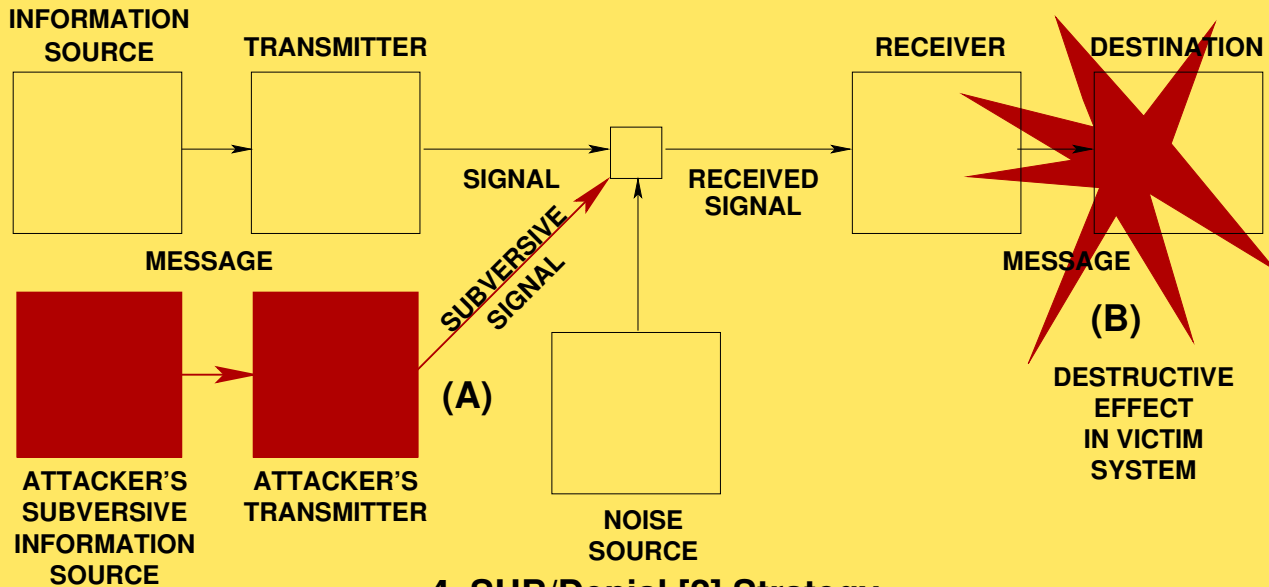
4. SUB/Denial [2] Strategy

Model for Exploitation Technique

INFORMATION SOURCE

TRANSMITTER

SIGNAL

RECEIVED SIGNAL

RECEIVER

DESTINATION

MESSAGE

MESSAGE

NOISE SOURCE
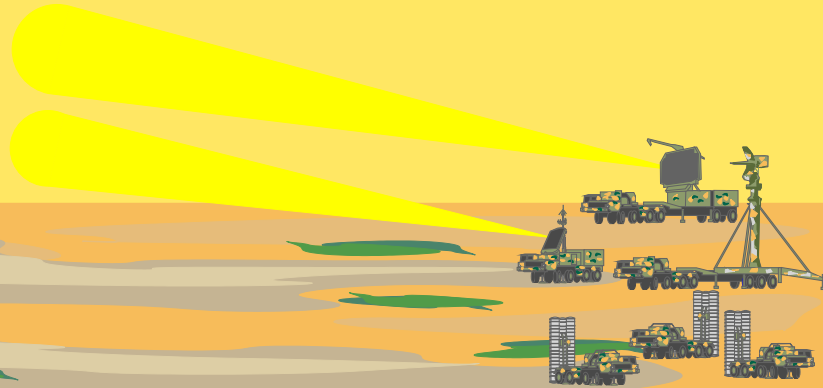
ATTACKER'S RECEIVER

ATTACKER
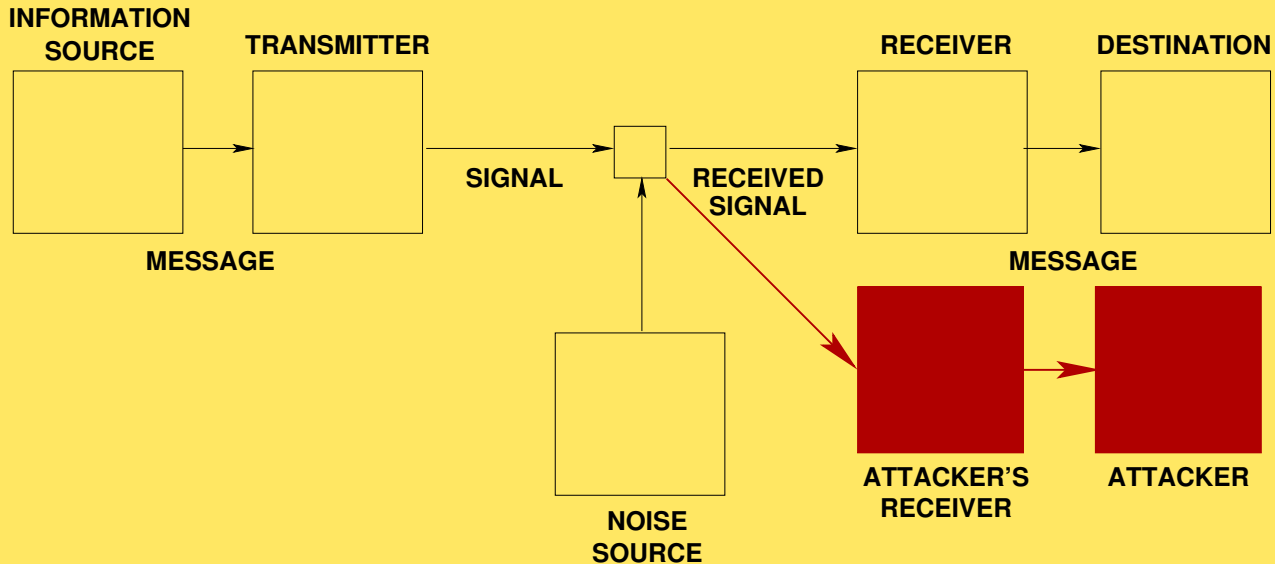
Exploitation Technique

Example of DoI/Degradation Strategy

1. DoI/Degradation Strategy

Background & Receiver Noise

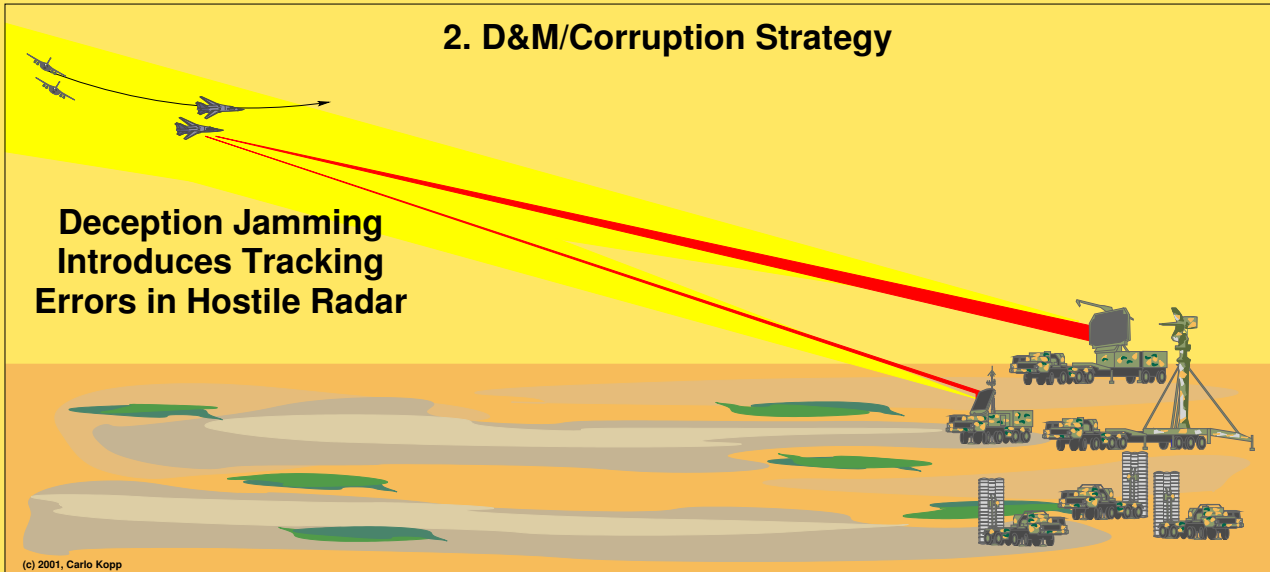**Stealth Technology Degrades Hostile Radar Performance**

(c) 2001, Carlo Kopp

Example of D&M/Corruption Strategy

2. D&M/Corruption Strategy
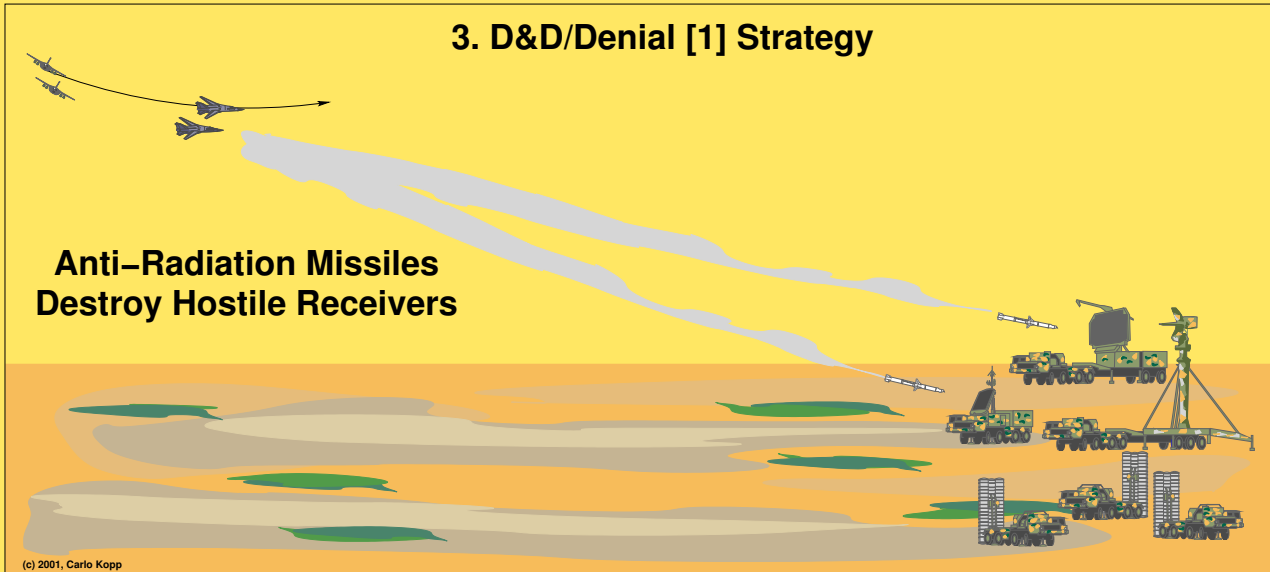
**Deception Jamming
Introduces Tracking
Errors in Hostile Radar**

(c) 2001, Carlo Kopp

Example of D&D/Denial (1) Strategy

3. D&D/Denial [1] Strategy

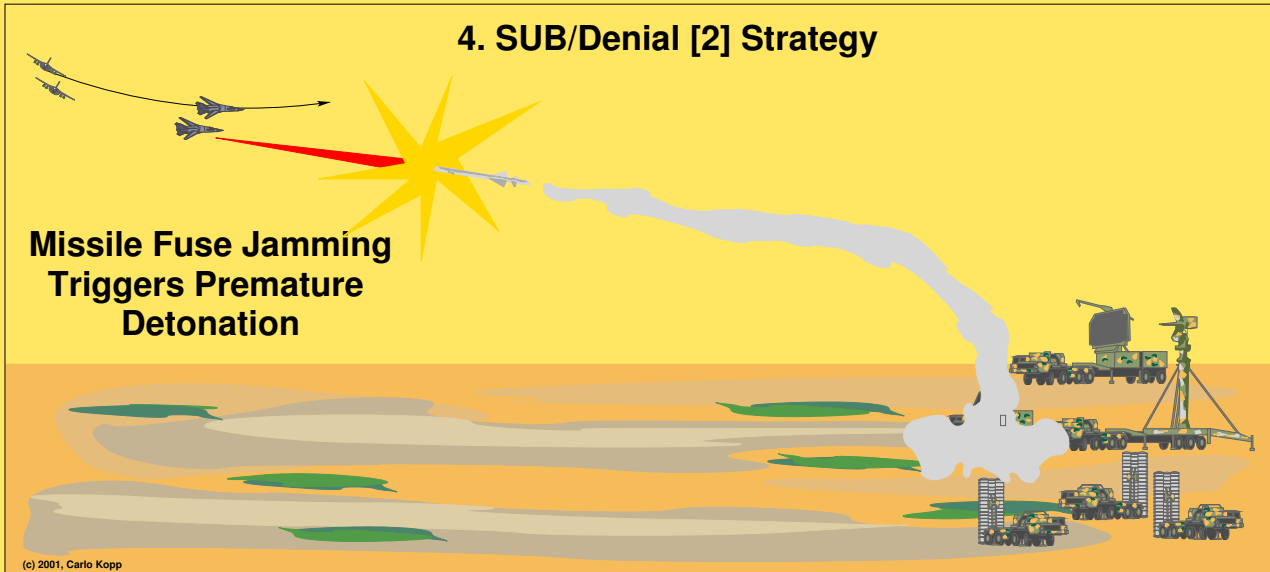**Anti−Radiation Missiles
Destroy Hostile Receivers**

(c) 2001, Carlo Kopp

Example of SUB/Denial (2) Strategy

4. SUB/Denial [2] Strategy

Missile Fuse Jamming Triggers Premature Detonation

(c) 2001, Carlo Kopp

Limitations of the Shannon Model

1. The Shannon model provides a powerful tool for capturing the interactions between adversaries and the information carrying channel.

2. *The Shannon model cannot capture how the manipulation of the channel might be reflected in the behaviour of the adversaries.*

3. How can we best model the interaction of adversaries given their use of some combination of the four canonical strategies?

Hypergames (Bennett/Fraser/Hipel)

Hypergames are games in which the respective adversaries may not be fully aware of the nature of the engagement they are participating in, or indeed that they are actually participating in an engagement. Characteristics include:

1. Players may have false perceptions of the intent or aims of the other players.

2. Players may not understand the choices available to other players.

3. Players may not know who other players in the game may be.

4. A player may be subject to one or more of the previous misperceptions of the game.

The 'perfect information' assumption does not hold for a hypergame.

Boyd vs Hypergames

1. Boyd (1986) defines the 'Observation-Orientation-Decision-Action' loop or 'OODA Loop' as a model for an engagement.

2. A player's perception of a game is described by the 'Observation-Orientation' phase of an OODA Loop.

3. A player's choices in a game are described by the 'Decision-Action' phase of an OODA Loop.

4. Boyd's OODA loop describes the basic dynamic in a Game/Hypergame.

Information Warfare is a means to an end in a hypergame - it permits alteration of an opponent's perception of the game in a manner yielding an advantage to the player using it.

The Game Model
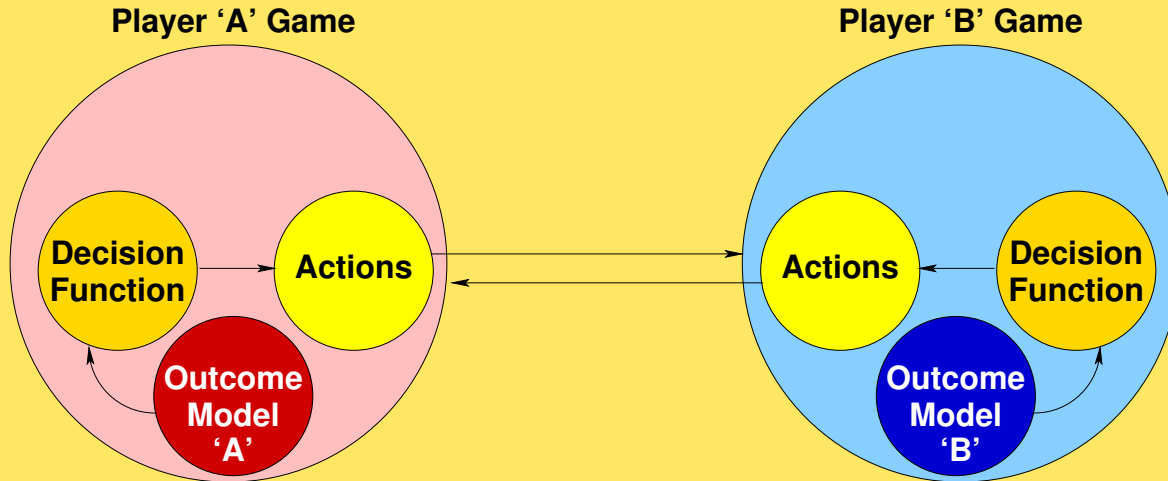
Model for a Game

The Hypergame Model (1)

Player 'A' Game

Player 'B' Game

Both Players Account for Adversary's Game Strategy

Perceived Model 'B'

Decision Function

Actions

Outcome Model 'A'

Information

Information

Perceived Model 'A'

Decision Function

Actions

Outcome Model 'B'

The Accuracy of the Perceived Games Depends on Available Information
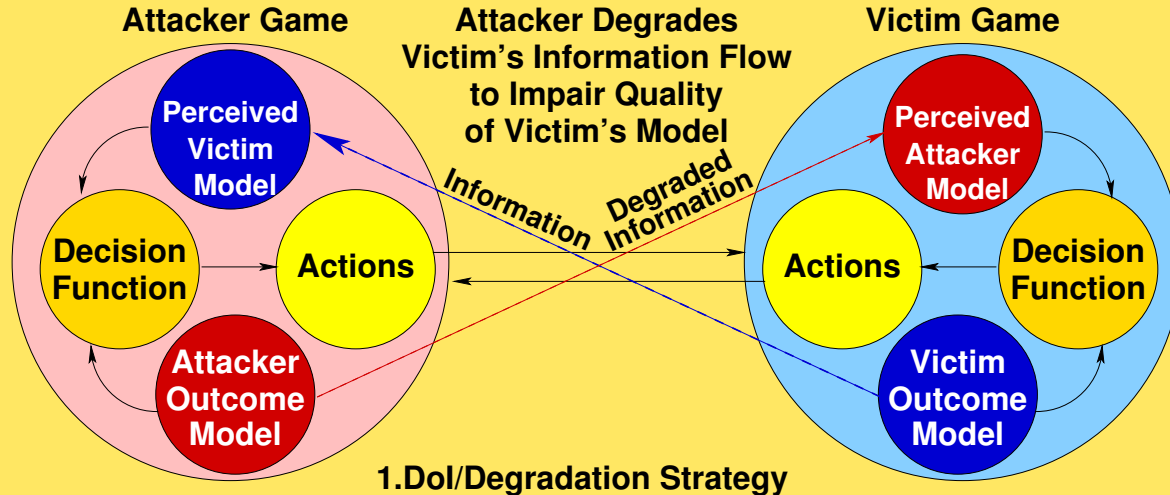
Model for a Hypergame
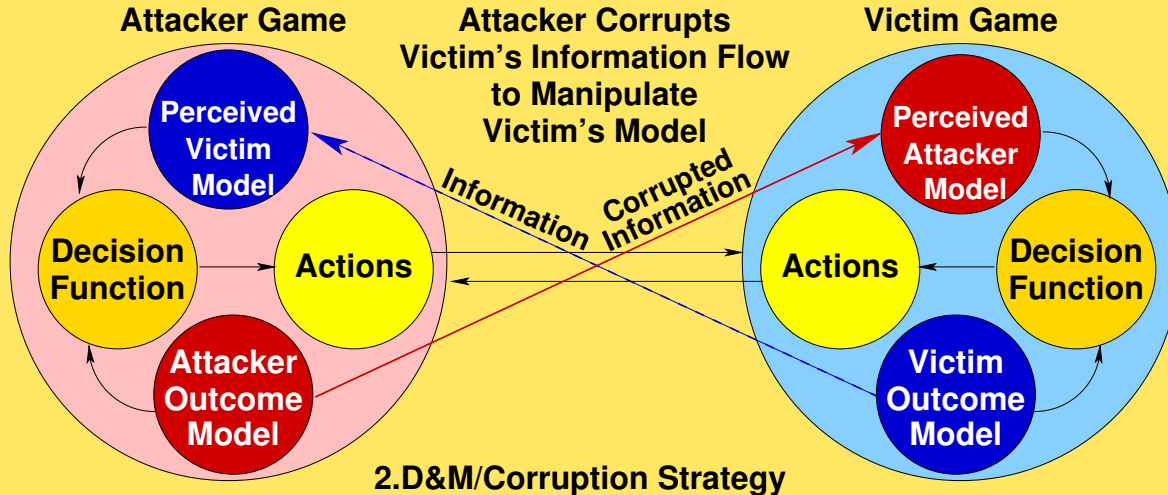
The Hypergame Model (2)

1. **Denial of Information**, this IW strategy is central to hypergames in which either the presence of a player, or the intent of a player is to be concealed from another.

2. **Deception and Mimicry**, is applied in a hypergame in order to alter another player's perception of the game at hand. It amounts to directly changing another player's perception of the game.

3. **Disruption and Destruction**, is applied by a player in a hypergame to prevent another player from perceiving the state of the game. D&D can betray the player using it.

4. **SUBversion**, is a strategy where a unilateral action by a player alters the perception of the situation by a victim player to elicit a self destructive unilateral action.

DoI/Degradation Strategy

1.DoI/Degradation Strategy

D&M/Corruption Strategy

Attacker Game

Attacker Corrupts Victim's Information Flow to Manipulate Victim's Model

Victim Game

Perceived Victim Model

Decision Function

Actions

Attacker Outcome Model

Information

Corrupted Information

Perceived Attacker Model

Decision Function

Actions

Victim Outcome Model

2.D&M/Corruption Strategy

D&D/Denial (1) Strategy

Attacker Game

Attacker Destroys Victim's Information Flow to Impair Quality of Victim's Model

Victim Game

Perceived Victim Model

Decision Function

Actions

Attacker Outcome Model

Information

Perceived Attacker Model

Decision Function

Actions

Victim Outcome Model

3.D&D/Denial [1] Strategy

SUB/Denial (2) Strategy

Attacker Game   **Attacker Manipulates Victim's Information Flow to Trigger Self Destructive Action**   **Victim Game**

Perceived Victim Model
Decision Function
Actions
Attacker Outcome Model

Information
Subversion Message

Perceived Attacker Model
Decision Function
Actions
Victim Outcome Model

4.SUB/Denial [2] Strategy
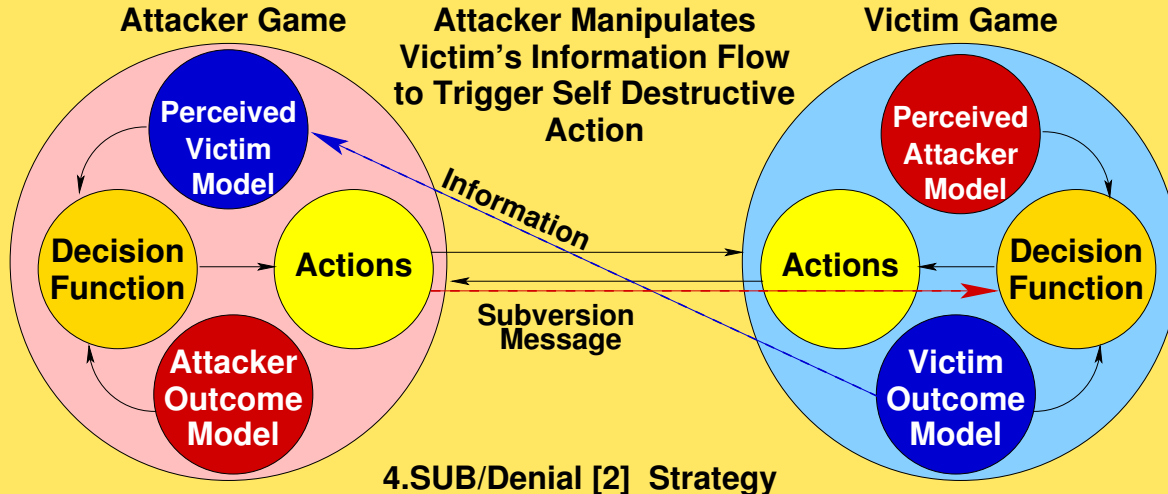
Conclusions

1. Shannon's paradigm of an information carrying channel provides a good basis for modelling the effects of Information Warfare.

2. The four canonical IW strategies can be readily modelled using Shannon's theory.

3. Hypergames provide a good model for representing interactions between adversaries executing IW actions.

4. Hypergames provide a good model for representing the dynamic of Boyd's OODA loop.

5. Future research should explore modelling such systems with higher order hypergames.

End Presentation

Revision Information

This document is currently at revision level:

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