Creating and Using Systems That Know Anything

August 2008

Dr. Richard L. Ballard
Chief Scientist
Focus of Technical Briefing

1. Origin of a Precise Theory of Knowledge
   Developed Over the Period 1987-1993
   By Dr. Richard Ballard

2. Development of That Theory Into A Third Generation Knowledge Tool
   Advanced Engineering 1993 - 2004
   Breakthroughs 2005 - 2008

3. Ballard / Shannon Limit Success
   Ability to Store Unlimited Knowledge
   In Absolute Minimum Space

4. Constraint Browsing -- Axiology
   Portraying And Judging Every Human Value And Necessity

Briefing Focus

Knowledge Foundations
Formulating A Precise Theory of Knowledge

Knowledge = Theory + Information

Dr. Richard L. Ballard  1987-1993
Knowledge As Evolutionary Science

Genes vs Brains

Impling Knowledge Type From Storage Type

Acquired Theory-based Knowledge

SENSE ORGAN receipt of Information produces physiological situation awareness-with or without a brain.

BRAINLESS animals react using their instinctive dna programs-to succeed or die.

Badly adapted species die out.
Knowledge As Evolutionary Science

Genes vs Brains

Adapted from The Dragons of Eden, Carl Sagan, 1977

Humans
Mammals
Reptiles
Amphibians
Jellyfish
Protozoa
Algae
Virus
Bacteria

Brain Knowledge Storage (Neural Bits)

Genetic Knowledge Storage (DNA Bits)

BRAIN memories model, store, and teach successful behaviors as "lessons learned."

They constantly adapt "brain content (Theory)" with no need to change the host's biological form.
Intelligent Animals Embrace Many "Behavior Patterns" For Their Self-evident Success

1. **Logical Self-consistency** insures machine-like behavior, following external mandates **ABSOLUTELY**.

2. Their proofs possess no intrinsic measures of: **efficiency, resource requirement, or complexity costs**.

3. Badly matched to a problem, their costs **CREATE "non-computability."**
Intelligent Animals Embrace Many "Behavior Patterns" For Their Self-evident Success

1. Extremely resource aware, their many possible goals are all Intentional, Competitive, Success-oriented, and often achievable in multiple ways.

2. They reject options that do not match their situation or go against theories they trust.

3. They expect most choices are not provably right or wrong, seek to enumerate all options, and predict the consequences of each option before deciding.
Abstraction
"the act of considering something as a general quality or characteristic, apart from concrete realities, specific objects, or actual instances"

-- Random House Dictionary

Aggregation
"collection of particulars into a whole mass or sum"

-- Random House Dictionary

Mark 3
Top-Most
Primitives

Everywhere
Imaginable
Every "Science"
Every "Fantasy"

Everything
Real &
Observable

Conceptualizing and Organizing
All of Imagination and Reality

Copyright Richard L. Ballard 1998-2007
Knowledge Theoretic Representations of Thought

The "a priori" rational constraints of belief and accepted theory

Mental Concepts & Methodology

The "a posteriori" constraints of observed fact, material existence, and recorded measurement

Copyright  Richard L. Ballard  1994-2006
Conceptualism & Semantics Replace Language

Properly implemented, **SEMANTIC WEBS approach** the absolute limits on size, speed, and efficiency.

**SEARCH** is an artifact of overloaded symbol use. In coded, declarative, semantic webs there is no search of any kind.

A CONCEPT (model-instance) appears only once in any semantic web, its unique code locates it instantly -- without search.
**Probabilistic "Practical Rationality"**

**Physical Theory of Knowledge & Computation**

"Information, Structure, Inference
-- A Physical Theory of Knowledge and Computation"

Dr. Richard L. Ballard, 1993

\[
P(a, b, c, \ldots x, y, z) = P(a, b, c, \ldots | \ldots x, y, z) \times P(\ldots x, y, z)
\]

**Theory-based Semantic Web**

**Real  it y**

**Physical Event of "Thought" or "Execution"**

Copyright Richard L. Ballard 1993-2006
Probabilistic "Practical Rationality"

Physical Theory of Knowledge & Computation
"Information, Structure, Inference
-- A Physical Theory of Knowledge and Computation"
Dr. Richard L. Ballard, 1993

Probability of Knowing Every Option Outcome Before Decisions Are Made

Probability of Predicting Outcomes for Every Choice

Probability of Recognizing Situation Correctly

\[
P(a, b, c, ..., x, y, z) = P(a, b, c, ..., | ... x, y, z) \times P(... x, y, z)
\]

Degrees of Freedom & Constraint
\(a'\text{priori}\) \(a'\text{posteriori}\)
\(a, b, c, ...\) \(... x, y, z\)

Goals
Education
Responsibility
Requirements
Intent

Time
Relation
Resource
Opportunity
Action

Theory-based Semantic Web

Physical Event of "Thought" or "Execution"

Copyright Richard L. Ballard 1993-2006
Knowledge As A Quantitative Hard Science

Physical Theory of Knowledge & Computation
"Information, Structure, Inference
-- A Physical Theory of Knowledge and Computation"
Dr. Richard L. Ballard, 1993

Theory-based
Semantic Web

DECISION IMPACT

PREDICTIVE WEB

SITUATION

\[ P(a, b, c, \ldots x, y, z) = P(a, b, c, \ldots | \ldots x, y, z) \times P(\ldots x, y, z) \]

Fundamental Ultimate Limit Measures

Knowledge = Theory + Information

Decision Success \( P(\text{task}) \)

\( a' \text{ priori} \) \( a, b, c, \ldots \)

\( a' \text{ posteriori} \) \( \ldots x, y, z \)
# Knowledge As A Quantitative Hard Science

**Physical Theory of Knowledge & Computation**

"Information, Structure, Inference

-- A Physical Theory of Knowledge and Computation"

Dr. Richard L. Ballard, 1993

## Theory-based Semantic Web

### Fundamental Ultimate Limit Measures

- **Knowledge Theory-based Ultimate Minimum Decision Resource Cost**
  
  \[-\log\{P(a, b, c, \ldots, x, y, z)\}\]

- **Ballard Education, Web Certification, & Theory Capture Limit Cost**
  
  \[-\log\{P(a, b, c, \ldots | \ldots x, y, z)\}\]

- **Shannon Information Bandwidth & Storage Limit Cost**
  
  \[-\log\{P(\ldots x, y, z)\}\]

## Theory predicts that costs can & will scale proportionally to Information Content

- **a’ priori**
  
  \[a, b, c, \ldots\]

- **a’ posteriori**
  
  \[x, y, z\]

## Theory provides performance-based measures comparing Education, Theory Capture, & Knowledge Creation investment

## Theory links task specific successes to most effective trade-offs in training, theory creation, & technology use

**Decision Success** \[P(\text{task})\]

---

**Quantitative Hard Science**

Copyright Knowledge Foundations 2006
On Creating A Third Generation Knowledge Tool

Advanced Engineering 1993 - 2004
Breakthroughs 2005 - 2008
Architectures
Mark 3 vs Conventional

• KFI-Mark 3
Theory-based Knowledge Integration

• Conventional Layer Cake
Code, Structure & Object Integration

©Knowledge Foundations, Inc./D.L. Thomas

Open source diagram
NEED TO MATCH CONCEPTS ACROSS ALL KNOWLEDGE SOURCES

Theory-based Semantics

Mark 3, Version 2: Design Objective

Copyright Richard L. Ballard 1993-2008
To Begin The Process Of Assessing
The Impact Of Every Situation

... x, y, z

SITUATION

\[ P(... x, y, z) \]

Multimedia Factsheets

Model:

- COUNTRIES
- COUNTRY/MILITARY FACILITIES
- MILITARY AIRFIELDS
- COUNTRIES/MILITARY FACILITIES/DEFENSE CONTRACTORS
- FACILITIES/SUB-COMPONENTS
- PROGRAMS
- ORGANIZATIONS
- MILITARY COMBINED TECHNOLOGY FACILITIES
- MAXIMIZATION: MODEL
- DEFENSE CONTRACTORS
- MILITARY ORGANIZATIONS
- GOVERNMENTS
- NATIONS
- MANUFACTURING ASSOCIATIONS
- MAJOR WAVE MANUFACTURING
- MAJOR WEAPONS
- VARIANTS
- POTENTIALS
- LIMITS
- RISK
- TECHNOLOGY
- Task Analysis

The Answer to Any Question is the Whole "Chain of Reasoning"

ACE CVN-77

Program Management

Knowledge Base 1998

Office of the Secretary of Defense

Countries

Model:

- COUNTRIES
- COUNTRY/MILITARY FACILITIES
- MILITARY AIRFIELDS
- COUNTRIES/MILITARY FACILITIES/DEFENSE CONTRACTORS
- FACILITIES/SUB-COMPONENTS
- PROGRAMS
- ORGANIZATIONS
- MILITARY COMBINED TECHNOLOGY FACILITIES
- MAXIMIZATION: MODEL
- DEFENSE CONTRACTORS
- MILITARY ORGANIZATIONS
- GOVERNMENTS
- NATIONS
- MANUFACTURING ASSOCIATIONS
- MAJOR WAVE MANUFACTURING
- MAJOR WEAPONS
- VARIANTS
- POTENTIALS
- LIMITS
- RISK
- TECHNOLOGY
- Task Analysis

The Answer to Any Question is the Whole "Chain of Reasoning"
To Assess Every Possible Option And Decision Impact

PREDICTIVE WEB

P(a, b, c, ... | ... x, y, z)

SITUATION

P(... x, y, z)

ASSUMPTIONS:

... x, y, z

ASSUMPTIONS:

... x, y, z

ASSUMPTIONS:

... x, y, z

ASSUMPTIONS:

... x, y, z

DECISIONS:

... x, y, z

DECISIONS:

... x, y, z

DECISIONS:

... x, y, z

DECISIONS:

... x, y, z

The Answer to Any Question is the Whole "Chain of Reasoning"
On Achieving Ballard / Shannon Limit Success

Ability to Store Unlimited Knowledge In Absolute Minimum Space
Google employs 450,000 servers, deployed in 25+ world locations, processing 20 petabytes per day.

Google processes its data on a standard machine cluster node consisting of two 2 GHz Intel Xeon processors with Hyper-Threading enabled, 4 GB of memory, two 160 GB IDE hard drives and a gigabit Ethernet link.

IBM mainframes build atop a myriad of database engines, sourced from a variety of DBMS vendors.

IBM mainframes focus on critical business applications such as: Human Resource Management (HR), Customer Relationship Management (CRM), Accounting, Supply Chain Management etc.

Large databases support 5,000 to 20,000 tables/fields to represent 1000s of abstracted concepts.

Servers are responsible for using 0.8% of world energy supply and 1.2% of US energy (2005).
Mark 3 is built upon absolute minimum, Shannon Limit size, and unlimited knowledge capacity. *No other tool can do this.*

Mark 3 is built upon a recognized theory of knowledge. It produces a complete description of all the information and theory needed.

Mark 3 supports a non-object oriented, theory-based description of knowledge, capable of describing anything, Real or Imagined.

Mark 3 moves directly to content. It employs no indexing or search.

Mark 3 is capable of describing every relationship between theories and objects.

Mark 3 enables the complete development and evolution of any and all knowledge systems.

Mark 3 creates a *Race to Reference Dominance*, building many layers of knowledge that can grow collectively to unlimited size.

*Knowledge Layers from Many Sources*
Employs Constraint Browsing

-Axiology-

Portraying And Judging Every Human Value And Necessity
Constraint Browsing

Medical Diagnosis
1 NOT FEELING WELL

There may be times when you may not feel well without being able to pinpoint a precise symptom. This feeling is commonly caused by the onset of a minor viral illness, psychological pressures, or just an unhealthy lifestyle. You should always consult your doctor if the feeling persists because there may be a more serious underlying problem.

START HERE

Have you lost more than 10 lb (4 kg) in weight over the past 10 weeks without a deliberate change in eating habits?

- Yes
- No

If yes, LOST OVER 10 LB (4 KG) OR MORE

Possible cause:
- Body changes that start to occur just after conception can make you not feel well (see COMMON COMPLAINTS OF NORMAL PREGNANCY, p.784).
- MEDICAL HELP
  - Make an appointment to see your doctor.

If no, LOST UNDER 10 LB (4 KG) OR LESS WEIGHT

Possible cause:
- Body changes that start to occur just after conception can make you not feel well (see COMMON COMPLAINTS OF NORMAL PREGNANCY, p.784).
- MEDICAL HELP
  - Make an appointment to see your doctor.

Are you currently taking any prescribed or over-the-counter medication?

- Yes
- No

If yes, MEDICATION

Possible cause:
- Your symptoms may be a side effect of the medication.
- MEDICAL HELP
  - Make an appointment to see your doctor. Stop taking any over-the-counter medicines but continue to take prescribed medication unless advised to stop by your doctor.

If no, NO MEDICATION

Are you feeling more fatigued than usual?

- Yes
- No

If yes, MORE FATIGUED

Possible cause:
- If you cannot identify a possible cause for not feeling well from this chart, make an appointment to see your doctor.

If no, NO CHANGE

Might you be pregnant?

- Yes
- No

If yes, POSSIBLE PREGNANT

Possible cause:
- You may have a mild digestive upset as a result of infection or having eaten something that disagrees with you (see GASTROENTERITIS, p.42).
- SELF-HELP
  - Avoid rich or spicy foods and drink plenty of clear fluids.
  - Consult your doctor if you do not feel better in 2 days or if other symptoms develop.

If no, NOT PREGNANT

Possible cause:
- Regularly drinking too much alcohol is likely to make you not feel well (see ALCOHOL AND HEALTH, p.62).
- MEDICAL HELP
  - Make an appointment to see your doctor for advice about reducing the amount of alcohol you drink.

Possible cause:
- Drinking more than the recommended limit of alcohol (see SAFE ALCOHOL LIMITS, p.82.)

- More than the limit
- Within the limit
- None of the above

Do you have any of the following symptoms?

- Loss of appetite
- Nausea
- Diarrhea
- None of the above

Go to chart 1 LACK OF APPETITE

Go to chart 2 FATIGUE

Go to chart 3 LOSS OF WEIGHT
Knowledge Browser identifies 13+ levels of diagnostics for the natural language question: "I don’t feel well."
This knowledge example from: "Complete Home Medical Guide." includes 8 levels not show, but listed above.

Start by choosing your costs first.

Control Dashboard

SELECTED CONCEPT

Diagnosis -- Not Feeling Well

RELATIONSHIPS

Diagnose 3-13

PATH NAMES

Diagnosis -- Not Feeling Well
Clicking on “Emergency” instantly limits the case being considered. The screen shows “Meningitus” as the primary threat. It indicates only *minutes to hours* to survive.
Selecting **Parameters Chosen** accepts all those 4 rows of conditions assumed. Then it chooses to look higher at the less significant symptoms.
As known results disappear from sight, the higher and less significant diagnostic choices are drawn. To help confirm the emergency diagnosis -- \textit{Meningitis}. 

![Diagram showing diagnostic choices and correlations for Meningitis diagnosis.](image-url)
As a backup, the slightly less “Urgent” choice is examined also. Here the critical time values extend to 2 weeks and 7-9 other diagnostic choices appear.
Once a diagnosis is determined, users can pursue treatment options at "the speed of thought."
Knowledge of every possibility is immediately available to every potential patient.

Start by choosing your costs first.

Not Feeling Well

Control Dashboard

SELECTED CONCEPT

Diagnosis -- Not Feeling Well

RELATIONSHIPS

Diagnostics 3-13

PATH NAMES

Diagnosis -- Not Feeling Well
Presenter:
Dr. Richard L. Ballard
Chief Scientist
Knowledge Foundations