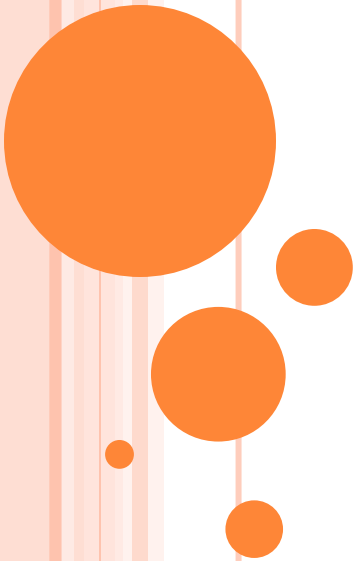


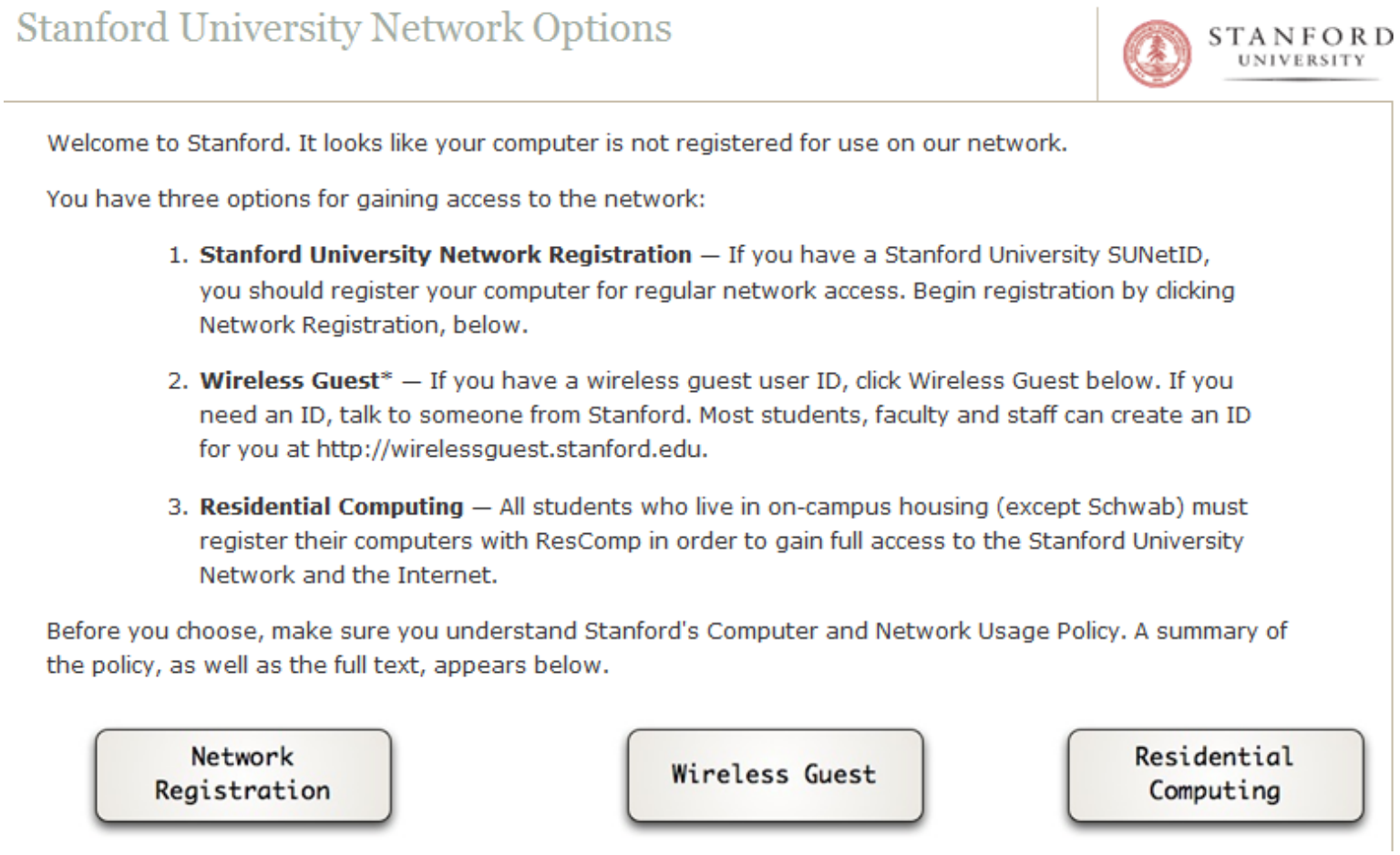
Ambient Connectivity

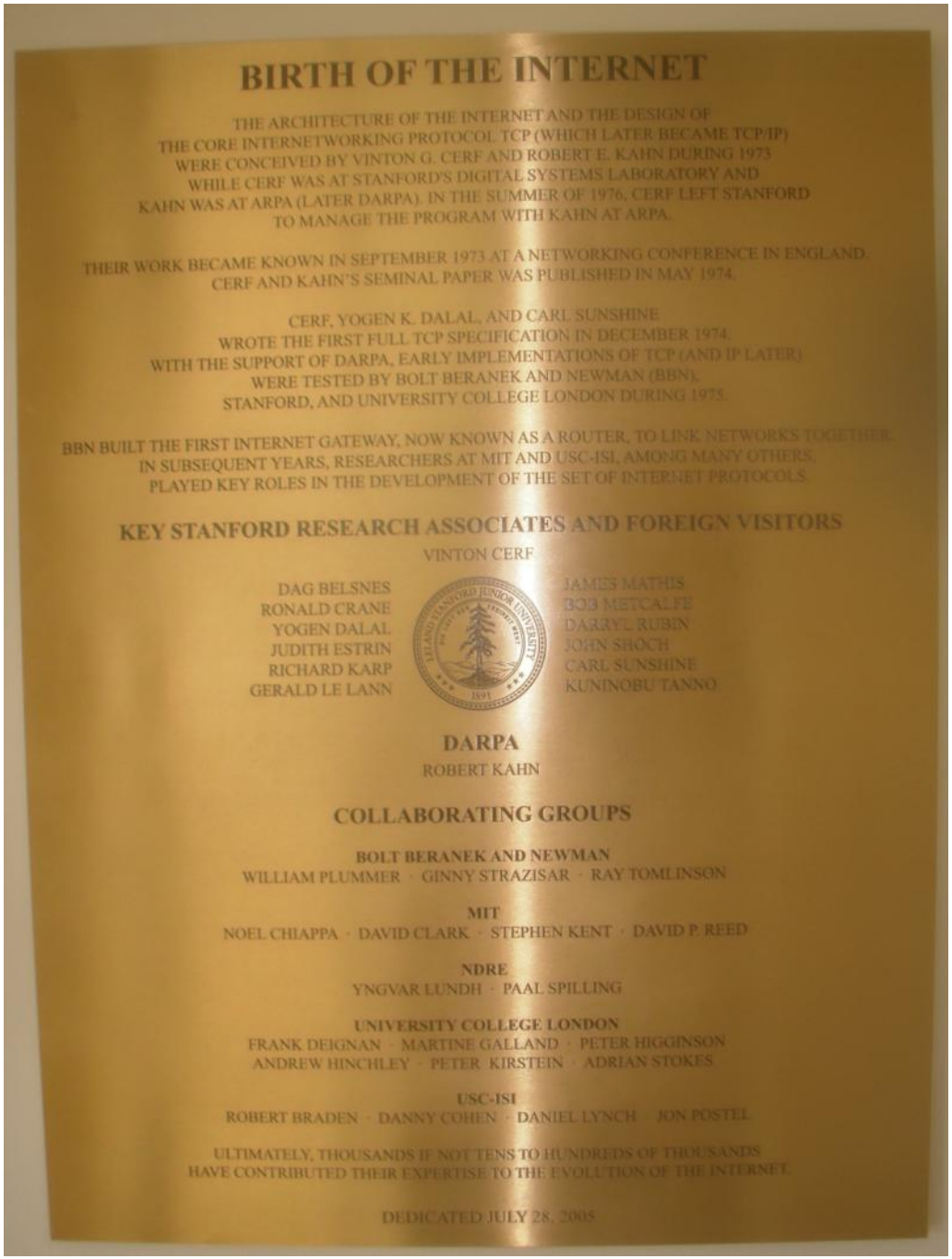
Bob Frankston, http://frankston.com (http://rmf.vc)

Achieving Ambient Connectivity

- The ability to assume connectivity
  - All the time
  - Everywhere
  - Apps “Just Work”

Not Ambient Connectivity





BIRTH OF THE INTERNET

THE ARCHITECTURE OF THE INTERNET AND THE DESIGN OF
THE CORE INTERNETWORKING PROTOCOL TCP (WHICH LATER BECAME TCP/IP)
WERE CONCEIVED BY VINTON G. CERF AND ROBERT E. KAHN DURING 1973
WHILE CERF WAS AT STANFORD'S DIGITAL SYSTEMS LABORATORY AND
KAHN WAS AT ARPA (LATER DARPA). IN THE SUMMER OF 1976, CERF LEFT STANFORD
TO MANAGE THE PROGRAM WITH KAHN AT ARPA.

THEIR WORK BECAME KNOWN IN SEPTEMBER 1973 AT A NETWORKING CONFERENCE IN ENGLAND.
CERF AND KAHN'S SEMINAL PAPER WAS PUBLISHED IN MAY 1974.

CERF, YOGEN K. DALAL, AND CARL SUNSHINE
WROTE THE FIRST FULL TCP SPECIFICATION IN DECEMBER 1974.
WITH THE SUPPORT OF DARPA, EARLY IMPLEMENTATIONS OF TCP (AND IP LATER)
WERE TESTED BY BOLT BERANEK AND NEWMAN (BBN),
STANFORD, AND UNIVERSITY COLLEGE LONDON DURING 1975.

BBN BUILT THE FIRST INTERNET GATEWAY, NOW KNOWN AS A ROUTER, TO LINK NETWORKS TOGETHER.
IN SUBSEQUENT YEARS, RESEARCHERS AT MIT AND USC-ISI, AMONG MANY OTHERS,
PLAYED KEY ROLES IN THE DEVELOPMENT OF THE SET OF INTERNET PROTOCOLS.

KEY STANFORD RESEARCH ASSOCIATES AND FOREIGN VISITORS

VINTON CERF

DAG BELSNES
RONALD CRANE
YOGEN DALAL
JUDITH ESTRIN
RICHARD KARP
GERALD LE LANN

JAMES MATHIS
BOB METCALFE
DARRYL RUBIN
JOHN SHOCH
CARL SUNSHINE
KUNINOBU TANNO

DARPA

ROBERT KAHN

COLLABORATING GROUPS

BOLT BERANEK AND NEWMAN
WILLIAM PLUMMER · GINNY STRAZISAR · RAY TOMLINSON

MIT
NOEL CHIAPPA · DAVID CLARK · STEPHEN KENT · DAVID P. REED

NDRE
YNGVAR LUNDH · PAAL SPILLING

UNIVERSITY COLLEGE LONDON
FRANK DEIGNAN · MARTINE GALLAND · PETER HIGGINSON
ANDREW HINCHLEY · PETER KIRSTEIN · ADRIAN STOKES

USC-ISI
ROBERT BRADEN · DANNY COHEN · DANIEL LYNCH · JON POSTEL

ULTIMATELY, THOUSANDS IF NOT TENS TO HUNDREDS OF THOUSANDS
HAVE CONTRIBUTED THEIR EXPERTISE TO THE EVOLUTION OF THE INTERNET.

DEDICATED JULY 28, 2005

History: Story 1
Arpanet Onward

- Network of Networks
  - **Problem:** Enable unanticipated concepts
  - **Challenge:** Middle has enumerated services
  - **Solution:** Packets and Best Efforts
  - **Idea:** End-To-End Argument
  - **Prototype:** IP with TCP/UDP
  - **Future?**
    - Improve extend?
    - Rethink/Reboot?

History: Story 2
User View

- University LANs Interconnected
- Extend via Dialup
  - ISDN vs.. Analog Modems
  - NATs
- Broadband!
  - BISDN?
  - Repurposed TV
- Internet morphed to reflect transport

History: Story 3
A New Understanding

- Economic Experiment
  - Remove the costs ($'s, effort etc) of connecting
  - Application Centric in theory but not really *End-to-End*
- The Internet as a Dynamic
- Failures
  - It can't define relations
  - Layering is too limiting
  - DNS and IP address are problematic

The Internet Dynamic

- Demand Creates Supply
- More capacity enables new apps (ex: The Web)
- VoIP starts to just work
  - If we had required VoIP we would've had to pay for path!
- Key Idea: Embrace opportunity, vs. requirements

A Different History: Telecom

- Starts with the Telegraph
  - Wires along railroad tracks
  - Telegraph like scribes
  - Facilities owned by providers
  - *It's in the image of railroads*
- Assumptions
  - We choose among enumerated services
  - Can identify the value of each message,
  - Even talking telegraph used message units
  - FCC modeled on the ICC

Concepts in Collision

Telecom	The Internet
Mired negotiating a path	Focus on the Application
Physical thing	Abstract concept
Is a thing	Does “Telecom” and more
Is Telecom	Is a dynamic
Financed by subscription	Just is, not a biz model
Common Carriage patch	Indifference ➔ Neutrality
Enumerated services	Opportunity
Shock and Awe	Simplicity
Owns the Infrastructure!	***Hostage to Telecom!***

Misunderstandings

- Internet only works were we have a path
  - Apps are decoupled from the path,
  - *In reality Broadband is just a convenient gully*
  - Connectivity **not** available almost everywhere!
- We confuse “Broadband” with The Internet
- Can’t shift paradigm if old one seems to work.
- Cyberspace??

Some Questions

- How long does it take to ship a toy across the country?
  - *Answer: A few seconds*
- How can you compress an encyclopedia?
  - *Answer: 10 digits if you use an ISBN number*

- What is the capacity of a foot of copper wire?
  - *Answer: If you can answer that you don't get it*

Ambient Connectivity

- The ability to assume connectivity
  - All the time; Everywhere
  - But not a guarantee (best efforts, resilience)
  - Wired, Wireless … bits don't care.
  - Not a network but rather facilitated networking
- Policy Implications
  - Infrastructure rather than billable paths
  - Can build on it for healthcare, education, safety etc

Architectural Considerations

- Focus is on enabling applications not the network
- Need stable relationships between end points
- Same behavior locally and globally
- Mechanisms vs. Policy (Trust, Social issues)
- Reflect social and real ambiguities

- ***Opportunity not promises***

Other Examples & Ideas

- Post Office
  - Stable routing system – addresses vs.. names
  - User maps names (intent) to stable end point
- Road System to Facilitate Travel
  - Implemented by communities at scale
  - Route numbers make them a system
- Examples: P2P, Skype
- **Decoupling rather than layering!**

A New Architecture

- There is no net – about ideas and conventions
- Relationships in terms of stable identifiers
- Directories and discover outside network
- Choose your own identifier (GUIDs (Random #))

The Physical Infrastructure

- Physical infrastructure facilities connectivity
- "Bit Commons" – normalize to bits
- Wired/Wireless – just mix and match
- Government's role at scale
- Far simpler if we don't need billable paths
  - Speech is not a consumable like electricity
  - Don't have the physical problems of roads
- First **Square** Mile, nothing to "access"

Internet ➔ Ambient Connectivity: *Policy*

- Harness expectation of fairness (Neutrality)
- Frame policy for opportunity not services
- Shift funding model to align incentives
  - Infrastructure funded as a whole (get $ back!)

Internet ➔ Ambient Connectivity: *Protocols*

- Start with Existing Protocols
  - With newly aligned incentives
  - Tweak protocols as needed
  - Fresh protocols as an “overlay” then “underlay”
- Fund research in new protocols policies
  - Of con artists and mistakes

Onward Outward

- Educate solution builders
  - Fundamental infrastructure, web as a minor app
  - Building connected devices as in pacemakers
  - Using the commons rather than, for example, “700Mhz”
  - Wired Logic ➔Decoupling relationships from wires
- Coming to grips with social topologies
  - Beyond Twitter, Facebook to real relationships
  - Leverage the familiar – geography ➔ topologies
  - Understanding new hazards and complexities of trust

For the Philosophers

- Operational abstractions
- Relationships are totally abstract
- Bits have no intrinsic meaning
  - *@StanfordEE380 What is the meaning of life?*
- Social policy and reality as interpretations.
- The Brain as an Endpoint. (http://rmf.vc/?N=RushHour1997)
- *Hmm …*