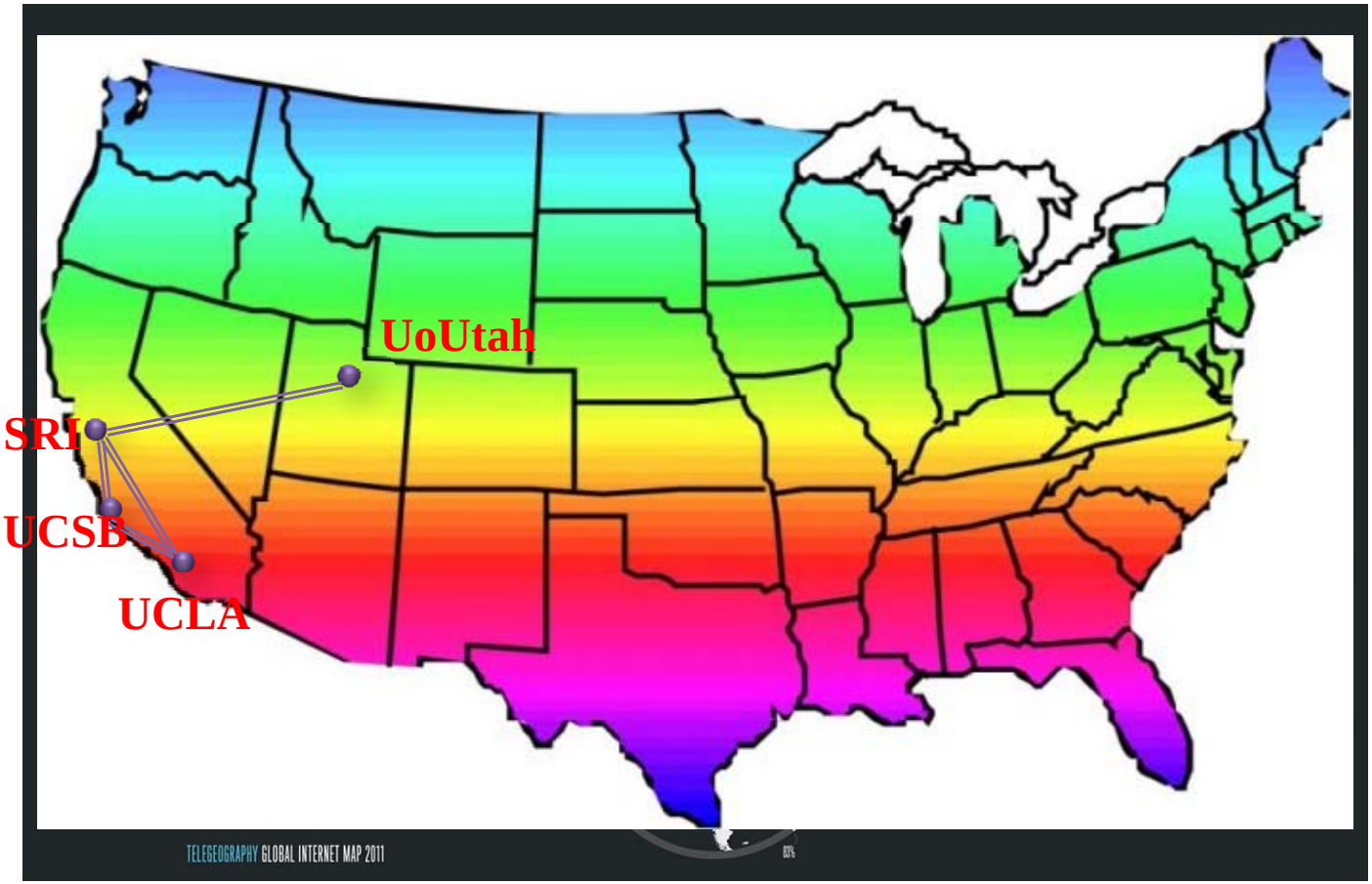
Can we evolve to next generation Internet ?
a model approach answer

Outline

- Why this work?
  - Background and motivations
- A brief glance at related work
- The definition of evolvability of the architecture
- The 2ACT model construction
- The 2ACT model based evaluation for content cache Mechanism
- Summary and extensions
  - What next?

40 years of grown

- Internet: a huge success!
  - global network infrastructure



40 years of grown

- Internet: a huge success!
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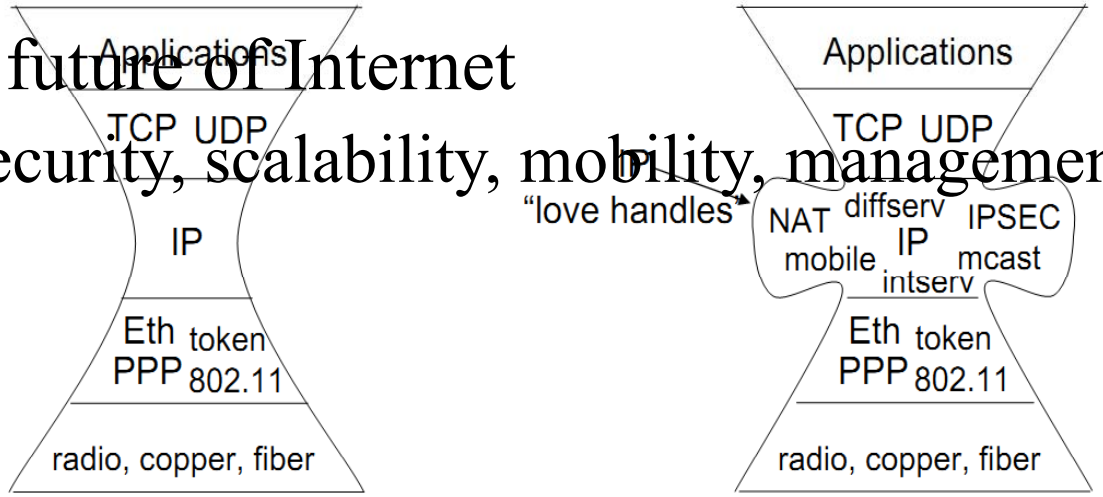
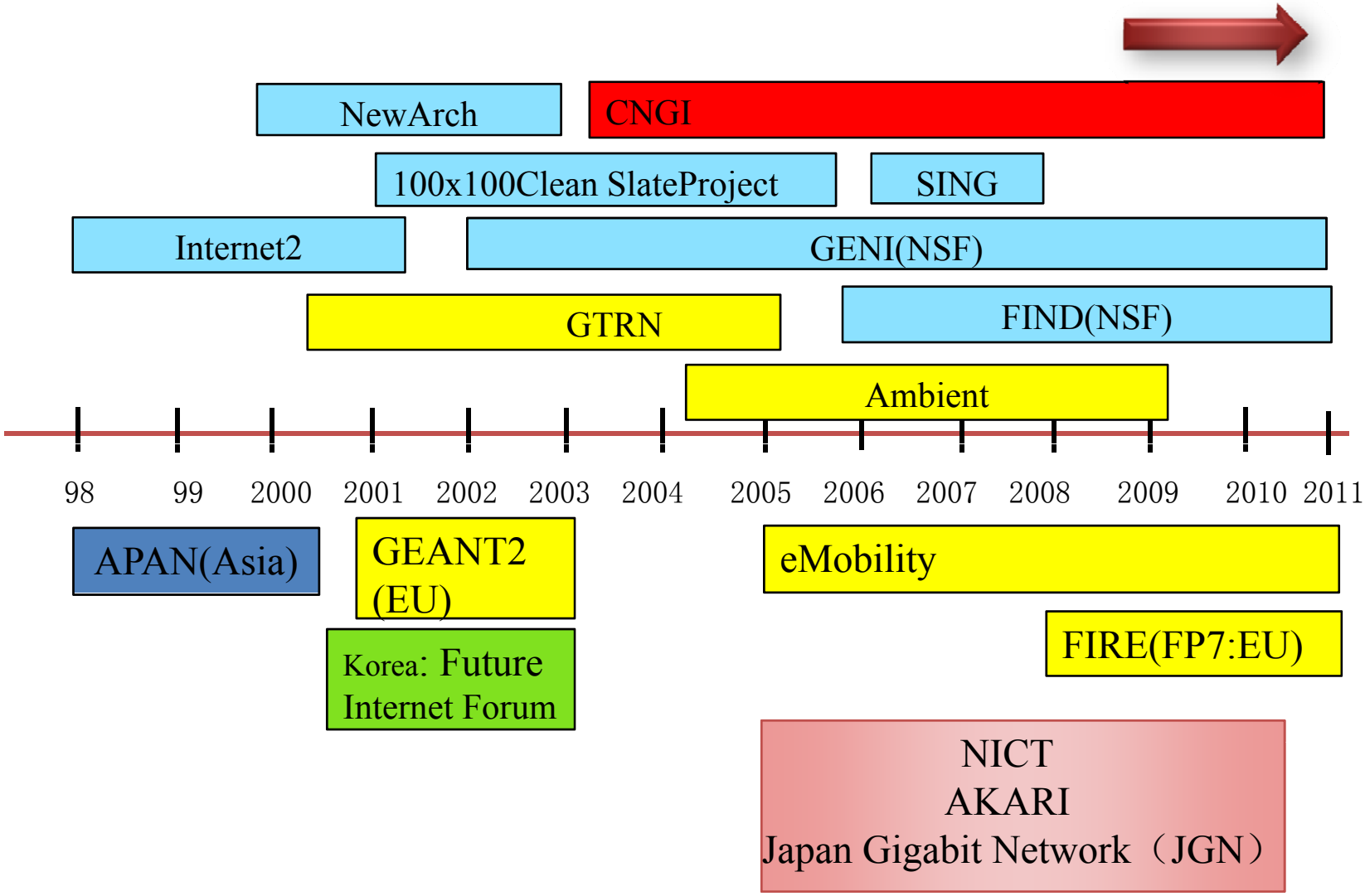
  - Improving of Protocol and hardware
- The future of Internet
  - security, scalability, mobility, management



"middle age Internet: a narrowing mind, a widening waist"

----Jim Kurose

Future Internet



40 years of grown

- Internet: a huge success!
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  - security, scalability, mobility, management
  - Clean-Slate?
  - Dirty-Slate?

Clean Slate ? Dirty Slate?

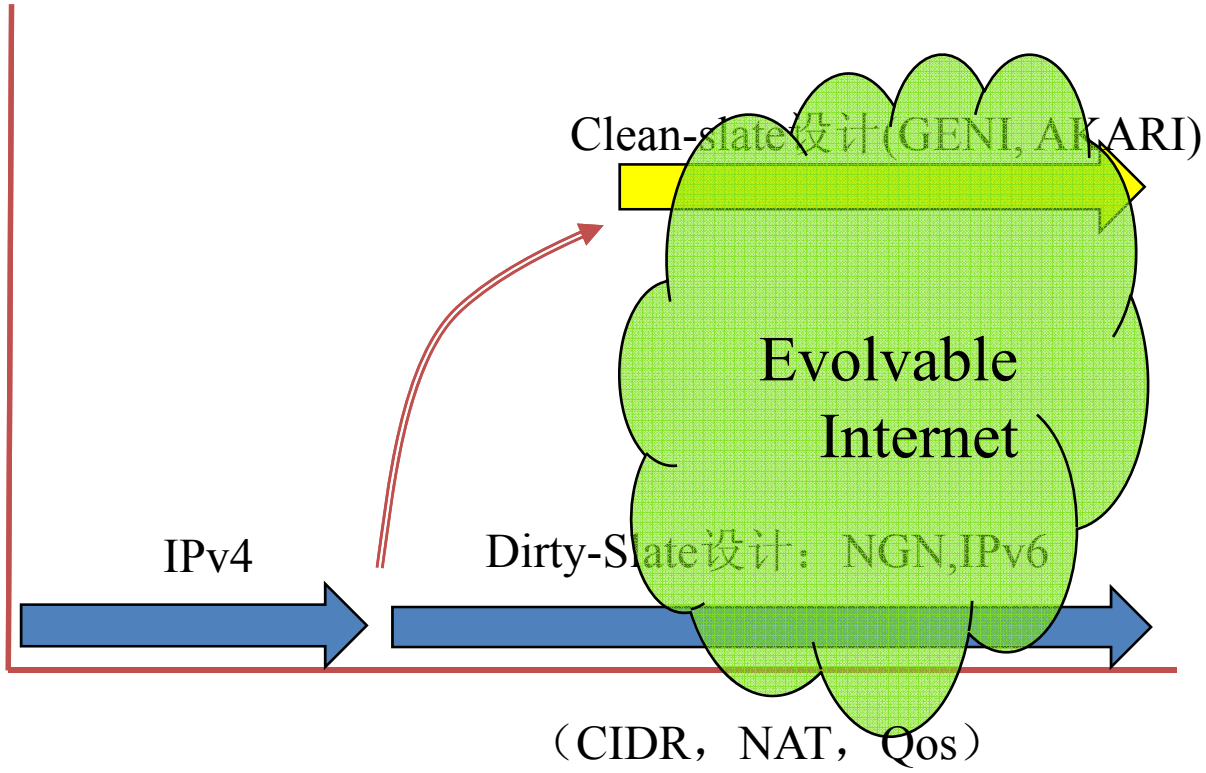
- Clean slate
  - break through all limitations
  - reinvent a new architecture
  - NDN, NewArch, GENI
- Problem 1： There is no feasible approaches that can be applied in real world
- Problem 2： Simulation model is relatively simple, lack of application experience

Clean Slate ? Dirty Slate?

- Dirty slate
  - Patch up, extending existing infrastructure
  - Incremental deployment
  - IETF
  - Internet 2, NGI
- Problem 1： complicated
- Problem 2： cannot address many inherent issues

TIPS-1

- Requirements in evolution of Internet Architecture
  - Stability (compatibility)
  - Scalability

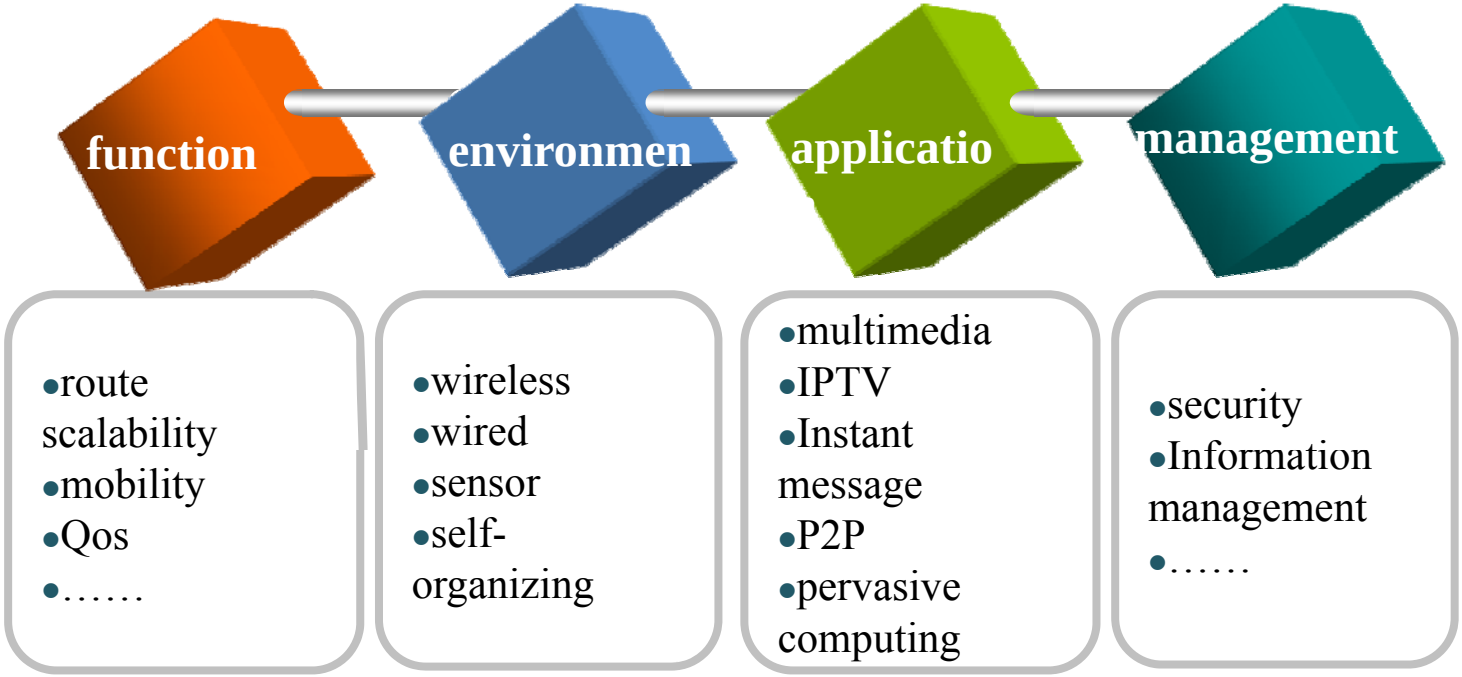


Can we evolve to the next generation?

- The essence of technology and successful experience of Internet is the root of its decades of rapid development and growth. Therefore, we should inherit and carry forward them in the next generation of Internet research.

– Rtp – Rsvp – http – Snmp – Dns – IP – UDP – Tcp	– telnet – ftp – Ospf – Bgp – Qos – Interserv – Diffserv – RSVP	– WWW – CDNs – Multicast – BGP – VoIP – SIP – DTN – ……

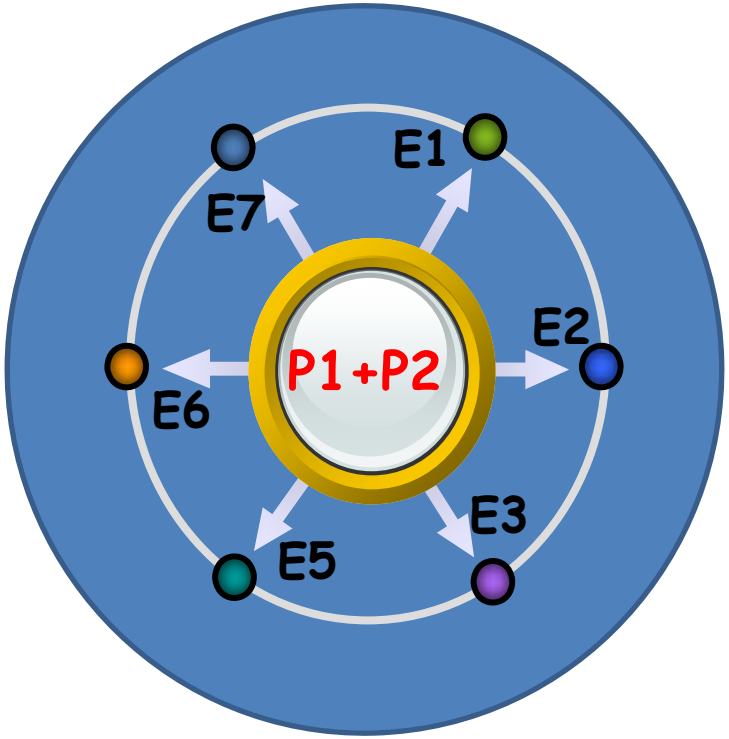
Can we evolve to the next generation?



- The evolution of Internet architecture needs to meet existing and foreseeable needs of future applications. Therefore, the evolution of Internet should not only keep the technology essence of the TCP/IP architecture, but also needs to introduce the advanced nature of clean slate.

The Definition of Evolvability Architecture

- Evolvability of Architecture: Internet architecture must be extended to generate new features for architecutre expansion by changing the basic elements which constraints the scalability.



- Kernel： P1+P2
  - P1:Connectionless packet switched
  - P2:end to end ?
- basic elements: change under limitation
  - E1:IP protocol
  - E2:name
  - E3:route
  - E4:transport
- Application protocol: change randomly

Evaluation Model

1.Game Theory & Evolutionary Dynamics tool

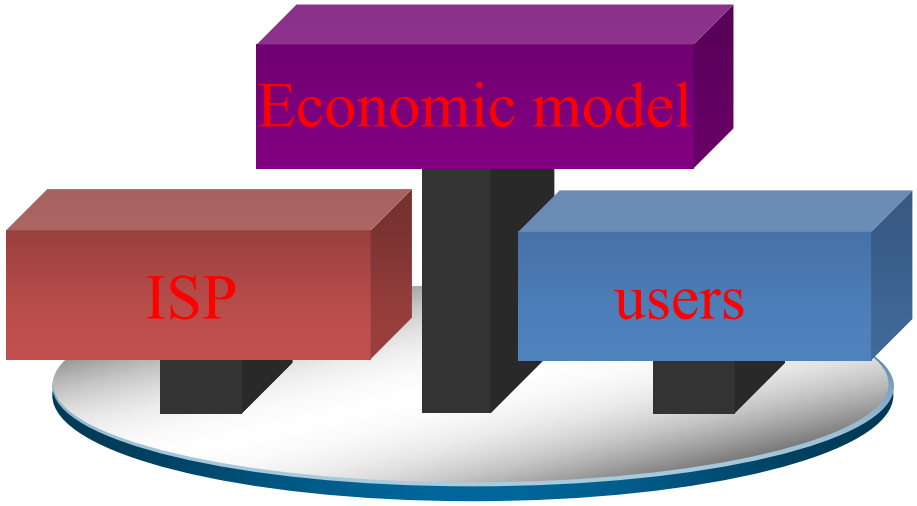
Laszlo Gyarmati uses game theory and evolutionary dynamics tool to analyze the IPv6 transition and deployment issues

2.Differential equation

Sen analyzes the impacts of different economic factors on the network architecture design, implementation and application

TIPS-2

- Traditional Evaluation Model

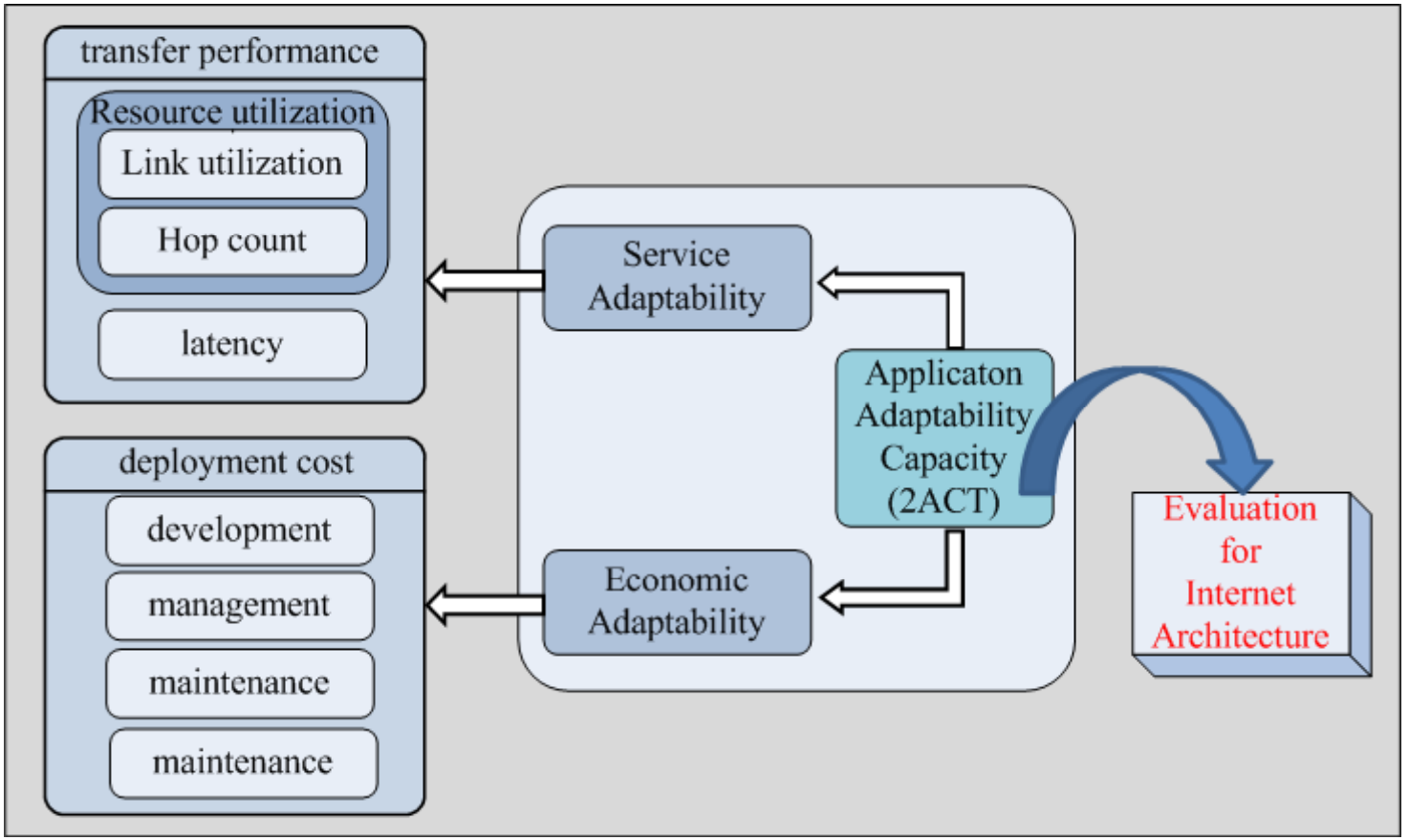


Game theory+Differential equation

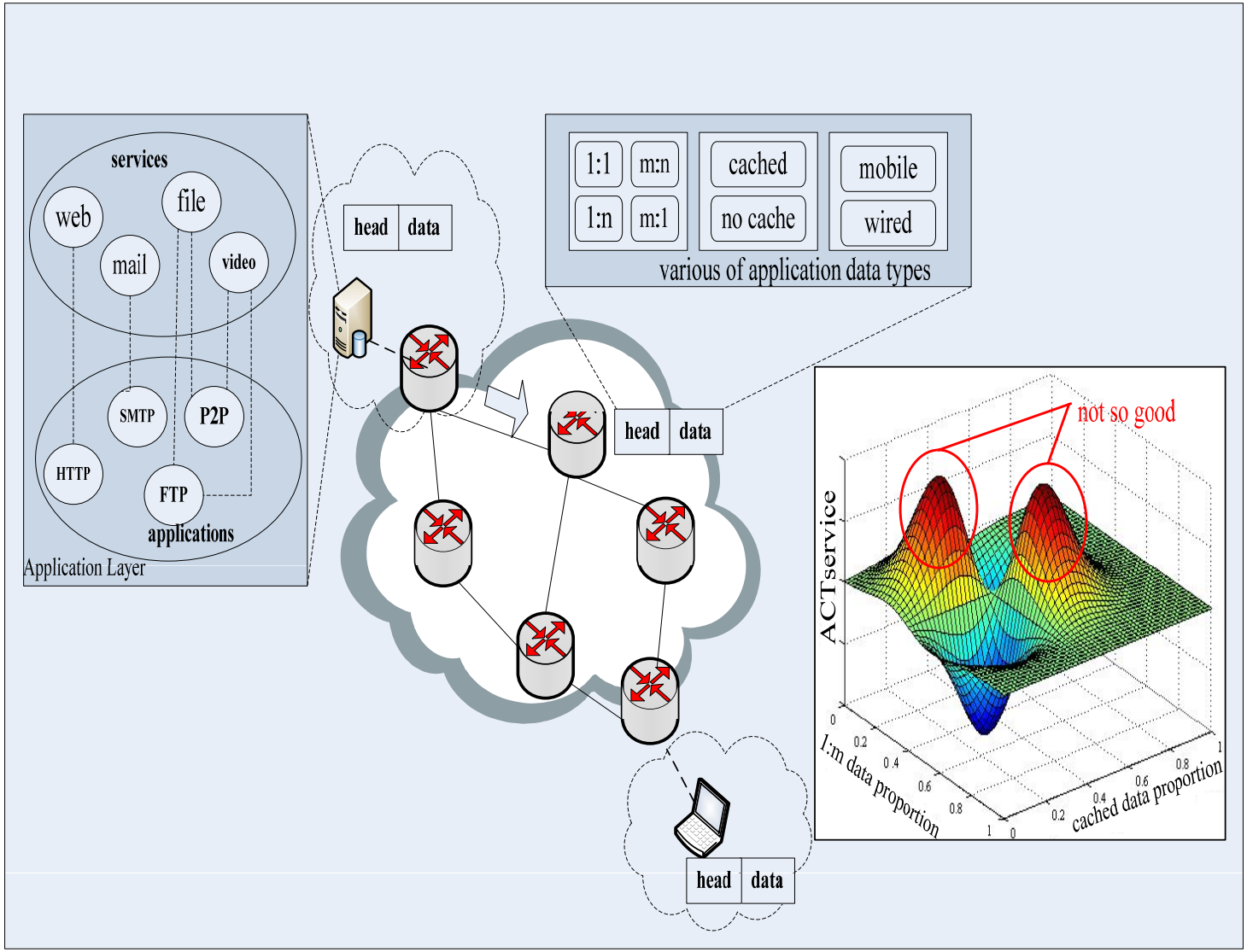
- the success of a new technology on Internet applications not only relies on the superiority of the technology, but also depends on the social, economic and other objective factors.

The 2ACT Model

- Application Adaptation Capacity (2ACT) of the Architecture
  - Service adaptability ($ACT_{service}$)
  - Economic adaptability ($ACT_{economic}$)



The service adaptability Model



The service adaptability Model

$$ACT_{service} = \frac{1}{m}\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij}\, f(H_{ij})$$

$$\text{s.t.} \quad \sum_{j=1}^{n} p_{ij} = 1$$

- **m : the number of application classifications**
- **n : the number of application types under a particular classification.**
- **p_{ij} : the proportion of application data under classification i and application type j in the network.**
- **f( ) : the performance and resource utilization function of the architecture when transmitting a unit of one particular type of application data. It can be represented by some performance parameter such as latency, bandwidth, link utilization etc.**

The economic adaptability Model

- Deployment cost: what the future Internet architecture is, it must be established on current architecture through upgrading, transformation or replacement.
- Maintenance and Management costs

$$\mathrm{ACT}_{economic} = C_{dep} + C_{mt}$$

The 2ACT Model Construction

$$\text{minimize} \quad 2ACT = \alpha ACT_{service} + \beta ACT_{economic} =$$

$$\frac{\alpha}{m}\sum_{i=1}^{m}\sum_{j=1}^{n} p_{ij} f(H_{ij}) + \beta(C_{dep} + C_{mt})$$

$$\text{s.t.} \quad \sum_{j=1}^{n} p_{ij} = 1$$

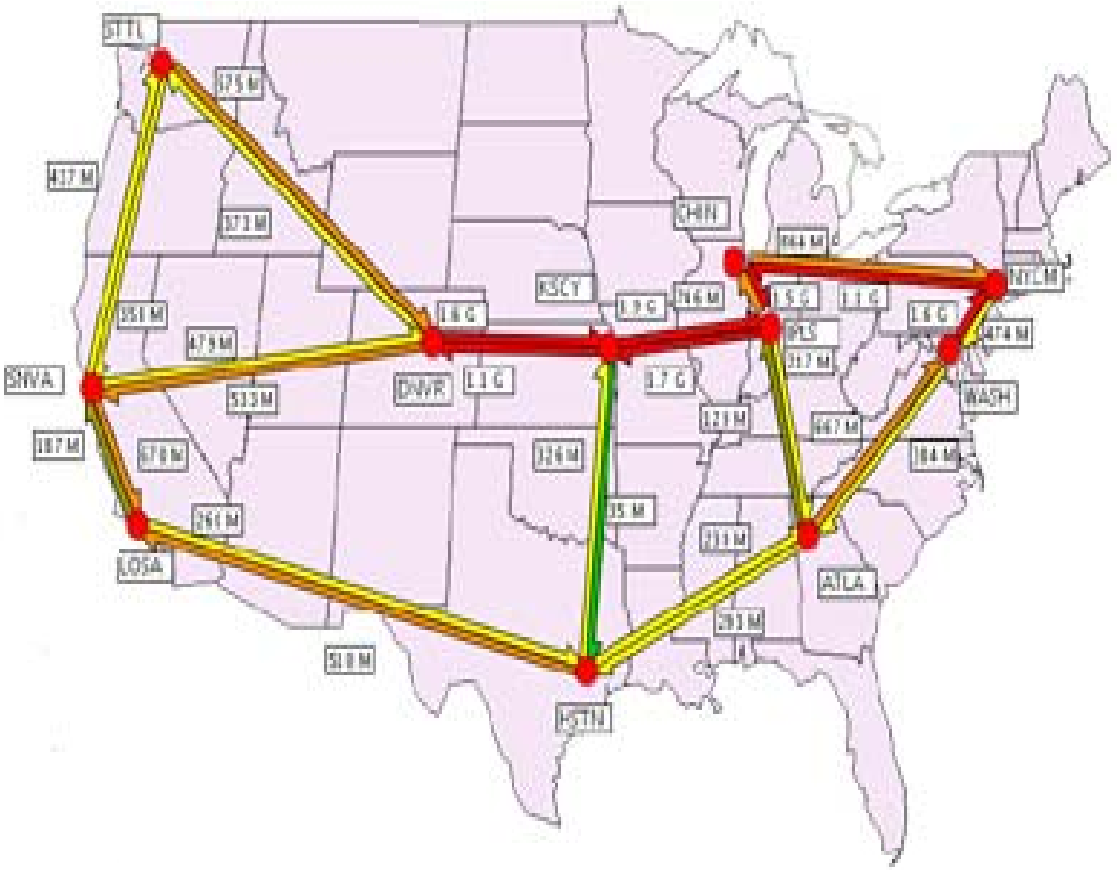
- α & β: used to weight the relative impact of application adaptability vs. economic adaptability on the evolution of architecture

The 2ACT Model based evaluation for content cache Mechanism

- Cisco Visual Networking Index (VNI) Forecast (2010-2015) report: “Internet video is now 40 percent of consumer Internet traffic, and will reach 62 percent by the end of 2015, not including the amount of video exchanged through P2P file sharing. ”
- Content Distribution
- users and most of applications do not care about the location of the required data ,
- performance improvement of the hardware and the reduction in the cost of storage and CPU

Content Cache, where -> who

The 2ACT Model based evaluation for content cache Mechanism

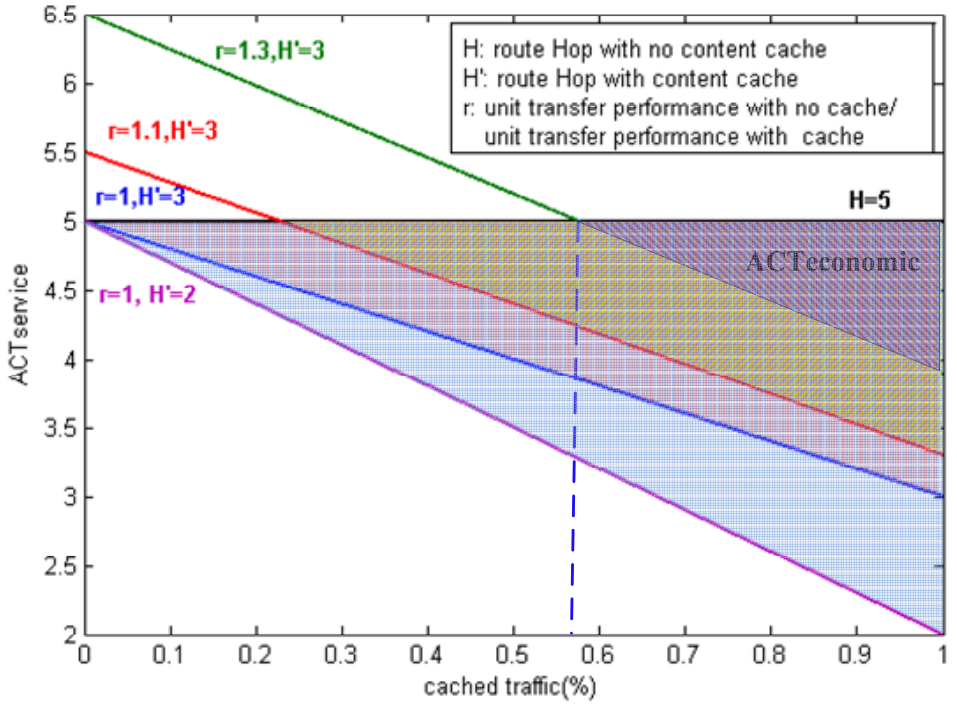


- H&H'(Abilene)：
  - H: 5。
  - H'<H

The 2ACT Model based evaluation for content cache Mechanism

$$ACT_{service(ordinary)} = 5\alpha Perf_{IP} + \beta C_{ordinary}$$

$$ACT_{service(cache)} = \alpha r Perf_{IP}(5p1 + 3p2) + \beta C_{cache}$$

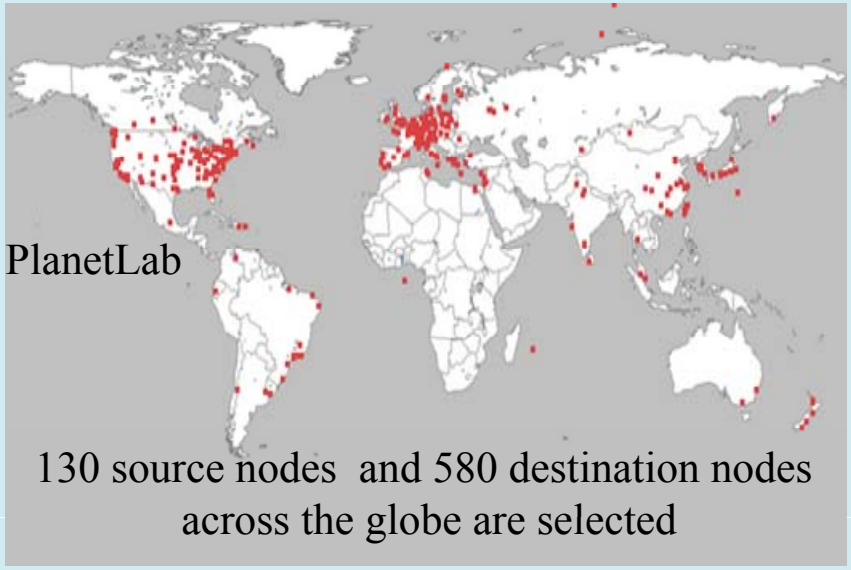


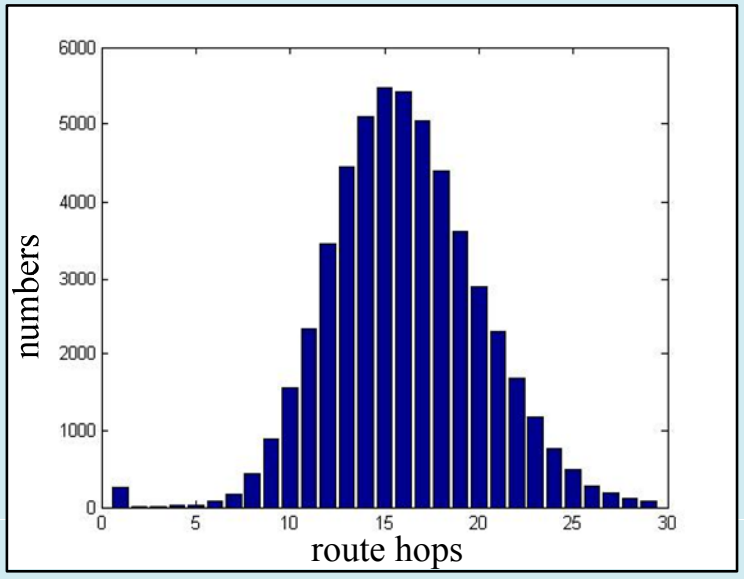
- Definitely route hop and economic cost:
  - The better the unit data transmission performance of the Content-based caching mechanism is (r smaller), the superior development potential is.
  - the content cache based architecture has poorer service adaptability when its unit data transfer performance is more than 1.3 times greater than the ordinary architecture, even if the cached traffic in the network has been up to 55% 。
- To content cache based architecture under some specific data transfer performance, the development potential is bad once its economic cost exceed the shadow area

Abilene

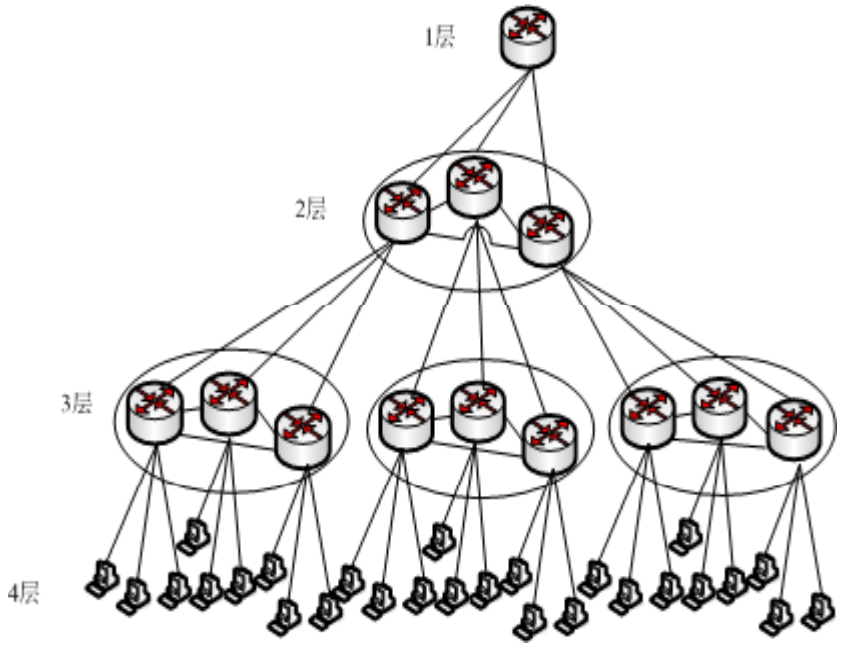
The 2ACT Model based evaluation for content cache Mechanism

- Average route hop in regular network H=16：
  - select 130 source nodes and 580 destination nodes randomly across the globe in the PlanetLab
  - the average route hop count in the PlanetLab is 16.





- H’(content cache based architecture)=7
  - K-ary tree
  - n: the height of the tree.
  - K^n: users, the leaf nodes of the tree.
  - $H = \sum_{i=1}^{n} 2i(K-1)K^{i-1}/(K^n-1)$: the average route hop

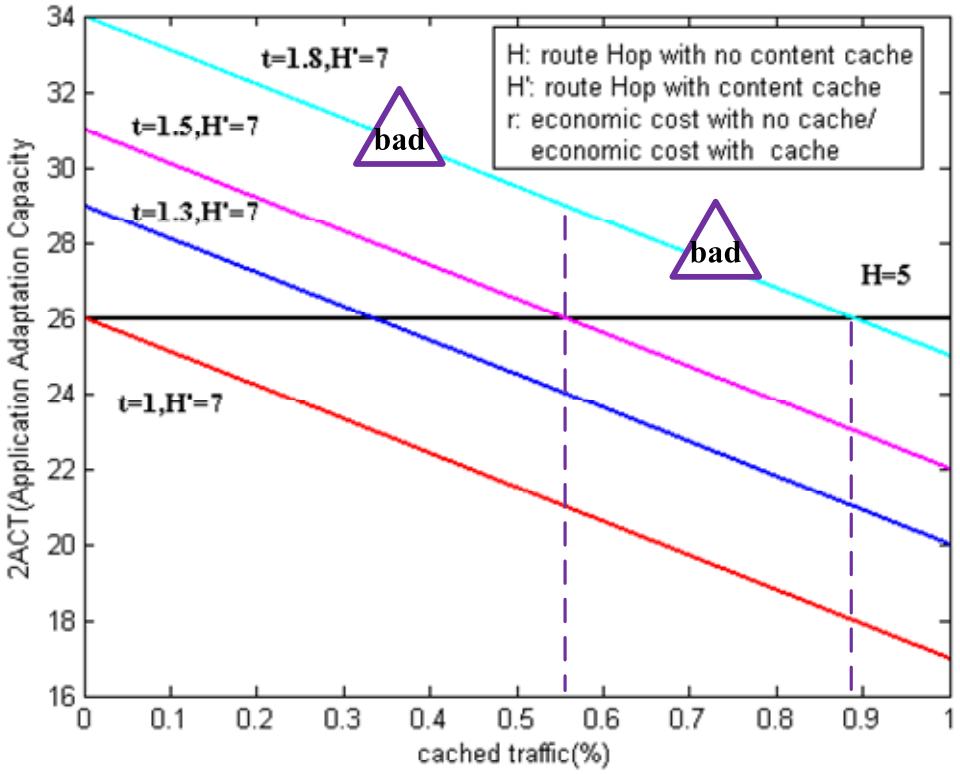


  - m different cacheable items, which are equally partitioned into k classes of popularity according to Zipf popularity distribution in the router: $q_k = C/k^{\alpha}, \sum q_k = 1$
  - average size of each classes is P, and each node in the network has a cache with size S, $d = S/P$,
  - the data cached in layer j : $A_j = \sum_{d(j-1)}^{d*j} q_s$
  - the average route hop $H' = \frac{K-1}{K^{n-1}} \sum_{i=1}^{n} K^{i-1} (\sum_{j=1}^{i} jA_j + 2i(1 - \sum_{j=1}^{i} A_j)$

The 2ACT Model based evaluation for content cache Mechanism

$$2ACT_{(ordinary)} = 16\alpha Perf_{IP} + \beta C_{ordinary}$$

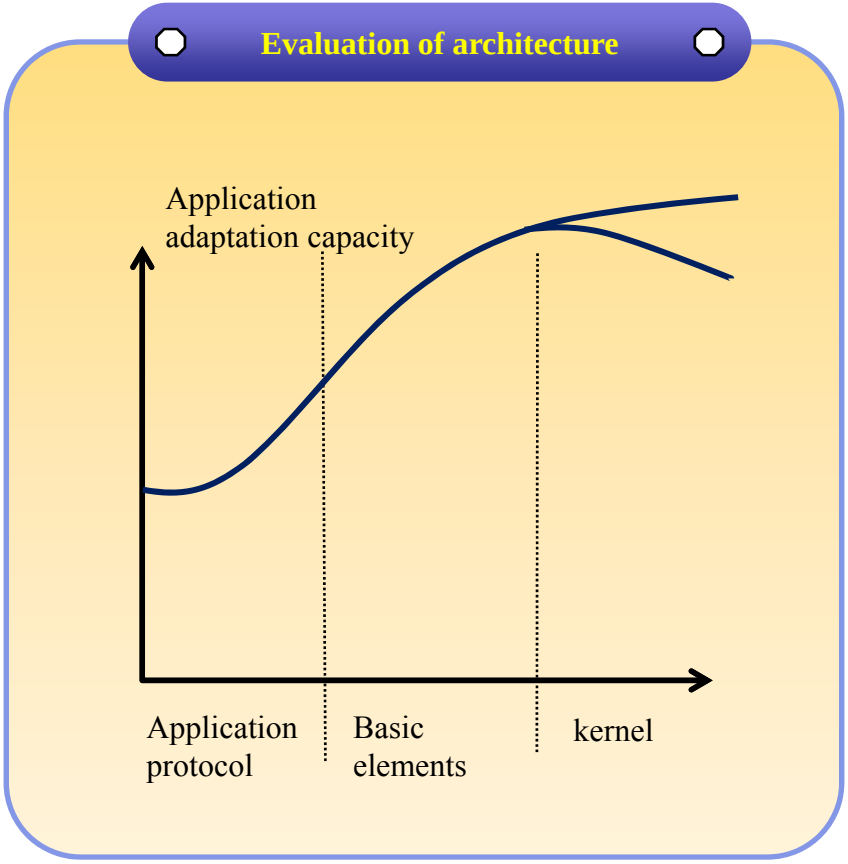
$$2ACT_{(cache)} = \alpha Perf_{IP}(16p1 + 7p2) + t\beta C_{cache}$$



- Definitely unit data transfer performance and route hop: Once the economic cost of content cache based architecture is more than 1.5 times larger than the ordinary architecture, the content cache based architecture is obviously not suitable for the network when the cached traffic proportion is lower than 60%.

PlanetLab

Summary & extensions



- summary
  - The evolvability of the Internet architecture definiton
  - The evaluation model based on application adaptation capacity of the architecture
- Future work
  - mean field
  - differential equation

Thank you!