Runtime Software Adaptation: Framework, Approaches, Styles

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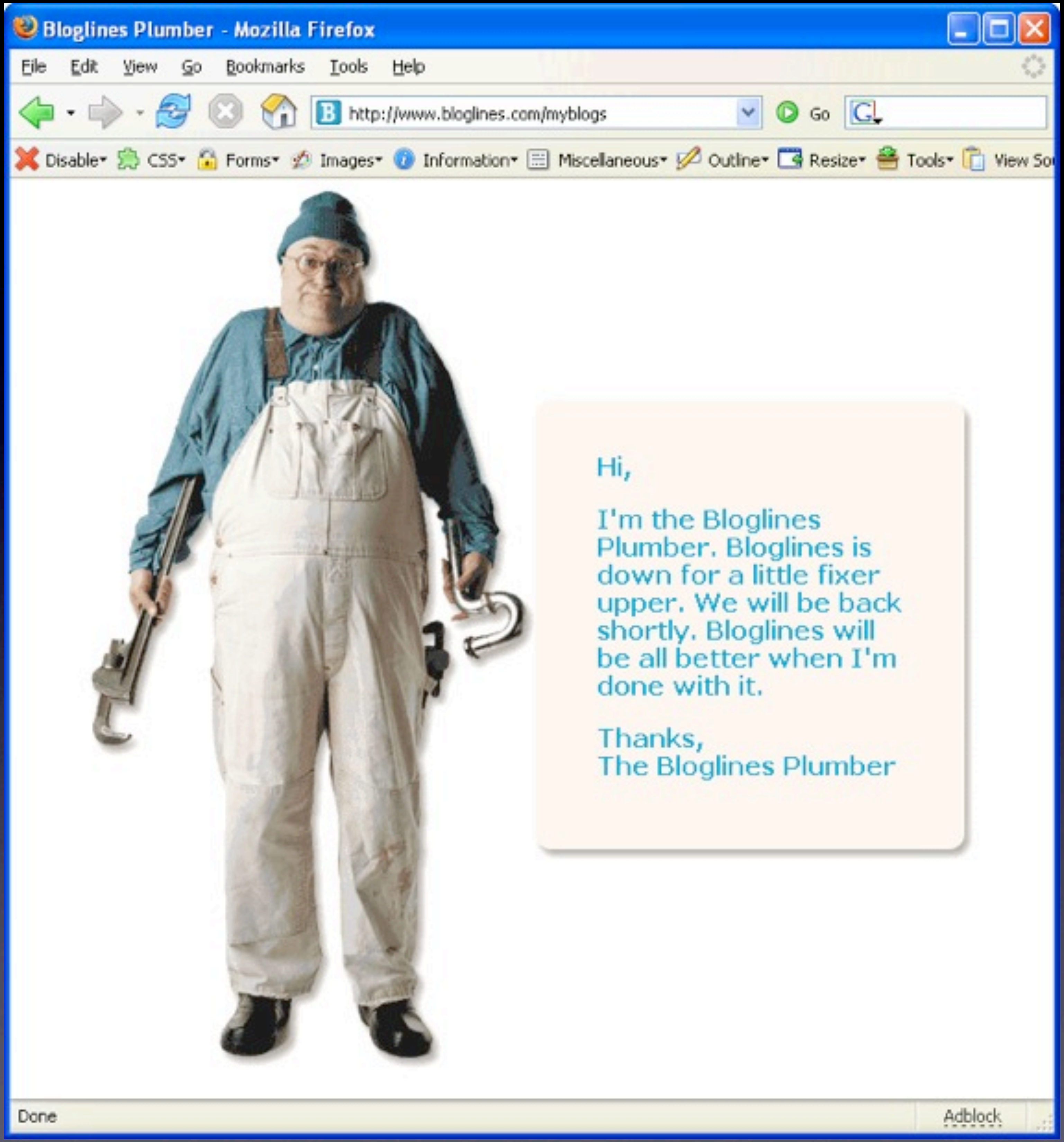
- 3rd thought: Could one person be responsible for all of them?

Change *during* runtime?

- Critical systems require “continuous availability”
  - Power grid, financial systems, ...
- Increasingly important in everyday systems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Thanks,
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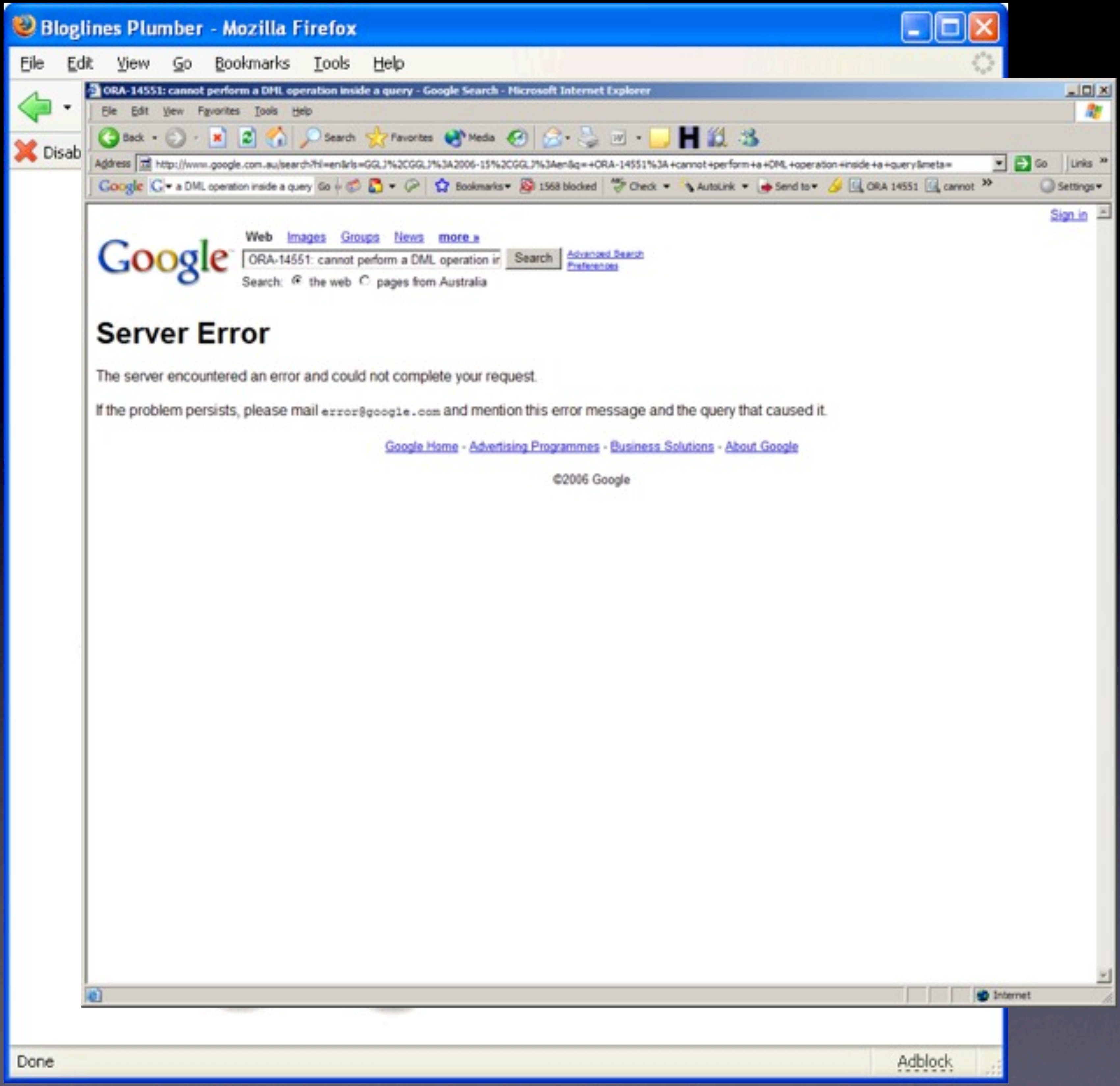
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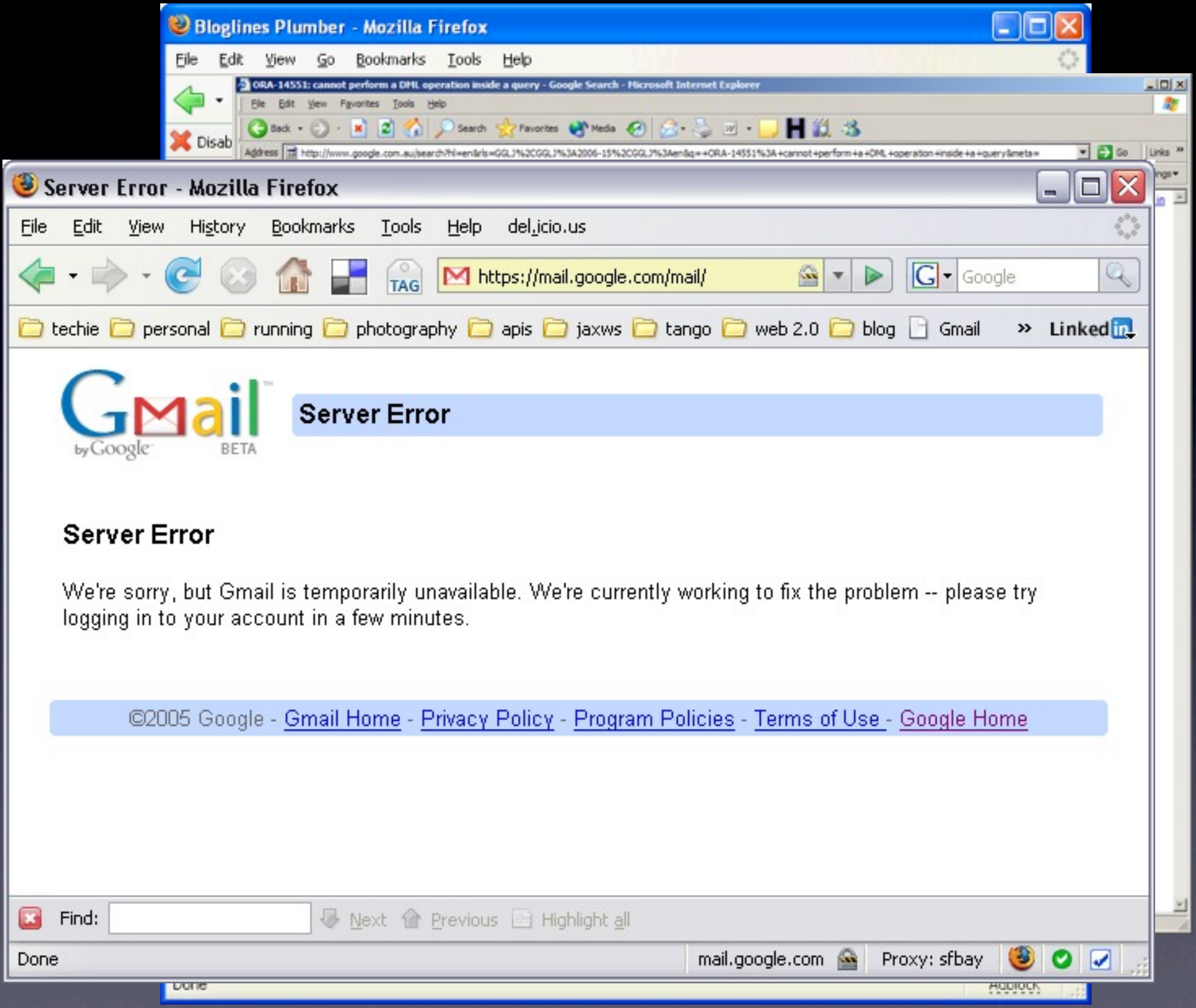
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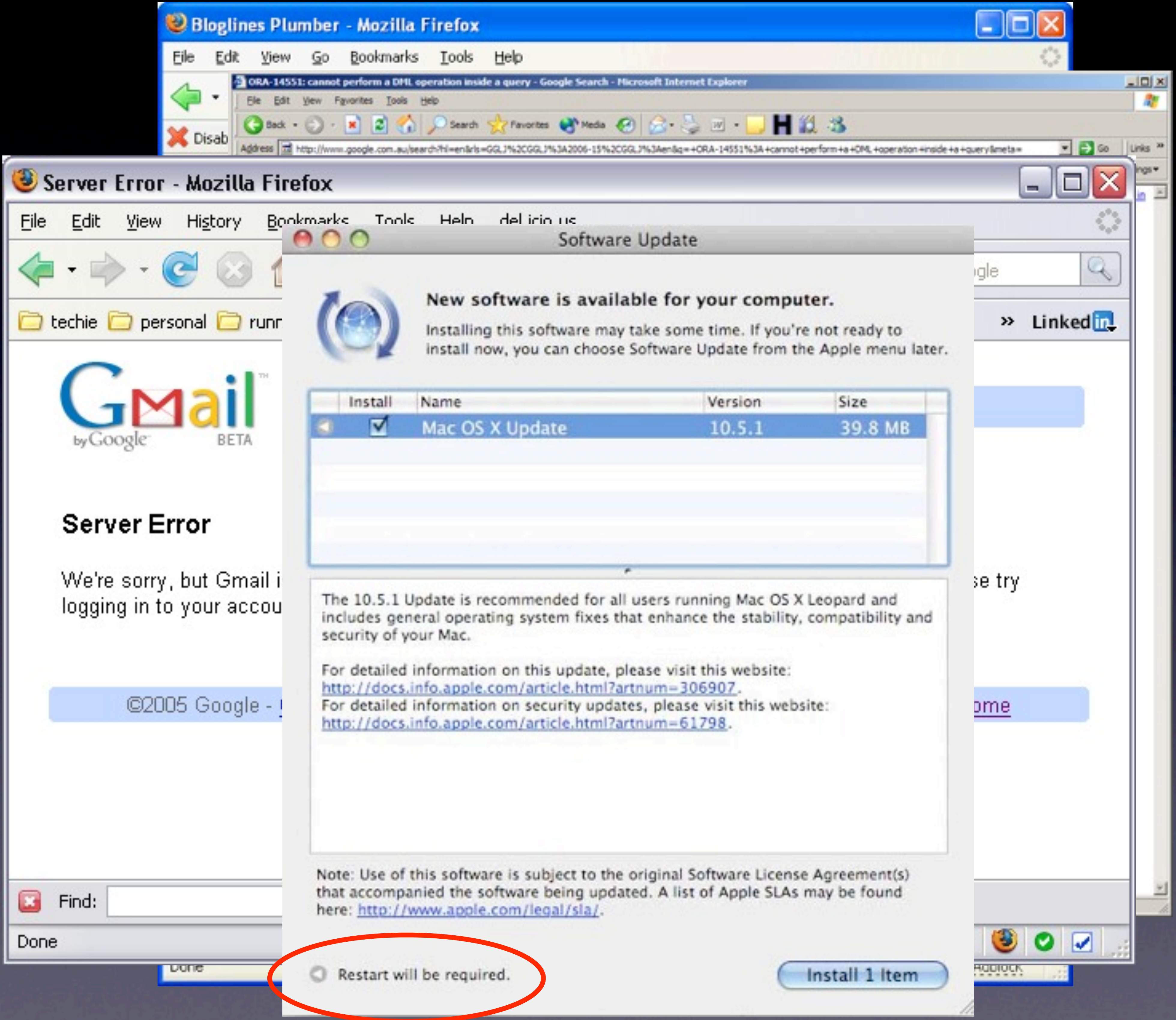
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New software is available for your computer.

Installing this software may take some time. If you're not ready to install now, you can choose Software Update from the Apple menu later.

Install	Name	Version	Size
✓	Mac OS X Update	10.5.1	39.8 MB

The 10.5.1 Update is recommended for all users running Mac OS X Leopard and includes general operating system fixes that enhance the stability, compatibility and security of your Mac.

For detailed information on this update, please visit this website: http://docs.info.apple.com/article.html?artnum=306907.
For detailed information on security updates, please visit this website: http://docs.info.apple.com/article.html?artnum=61798.

Note: Use of this software is subject to the original Software License Agreement(s) that accompanied the software being updated. A list of Apple SLAs may be found here: http://www.apple.com/legal/sla/.

Restart will be required.

How did we get here?

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- Serendipity

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- Key insights:
  - connectors
  - explicit arch-model fielded with the system and used to govern change
  - architectural style

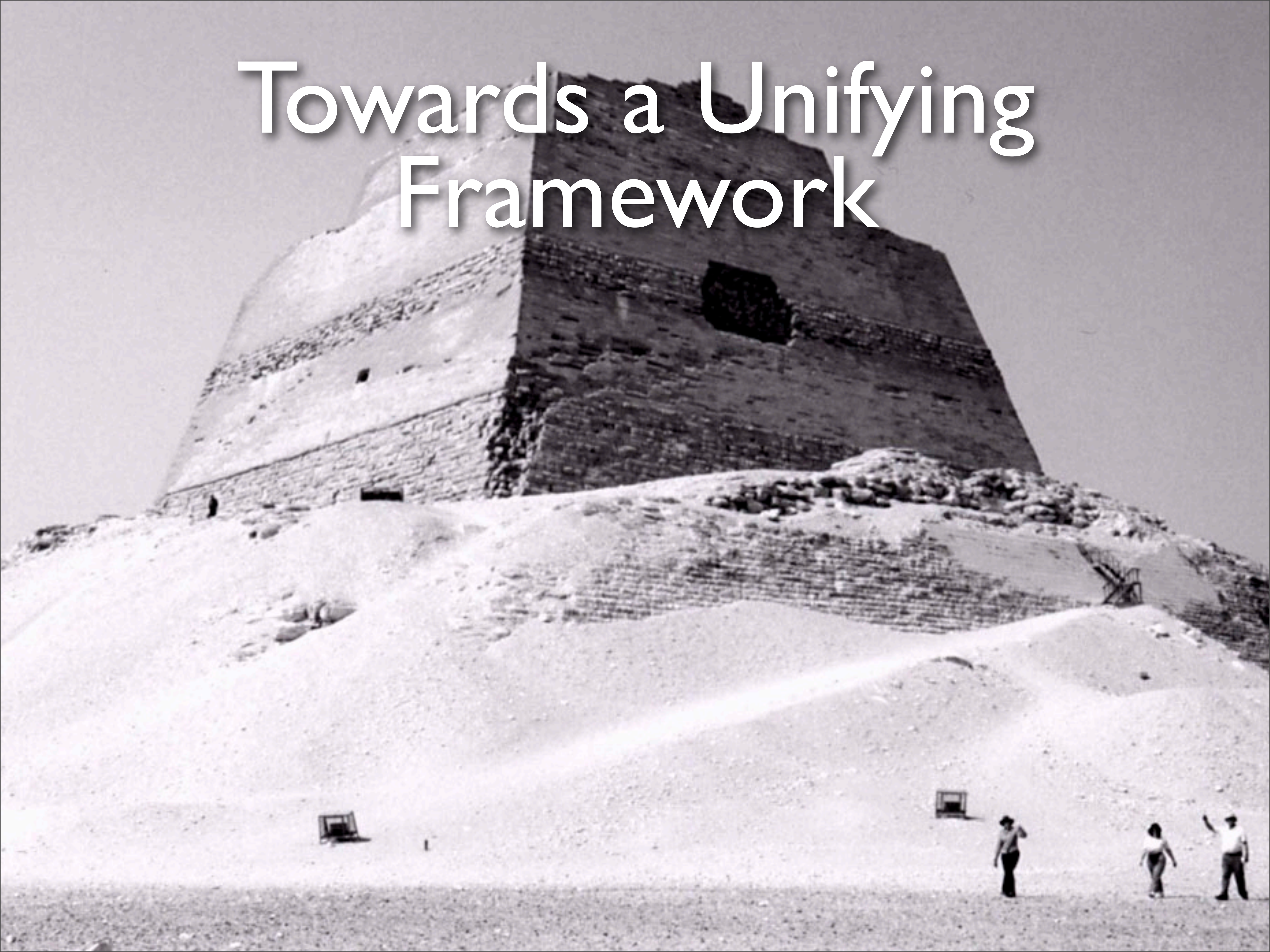
State of the Practice

- redundant and fault-tolerant hardware
- “hot pluggable” drives and memory
- system virtualization (ala VMware and Xen)
- binary code patching
- programming language facilities for dynamic loading, linking, and patching of code
- software designed for fault tolerance (architectural styles and patterns)

State of the Practice

- Each approach has its place
  - No one approach encompasses the others
  - Clear benefits to enacting change at multiple levels of abstraction
- Need a framework for *comparing and combining* approaches

Towards a Unifying Framework



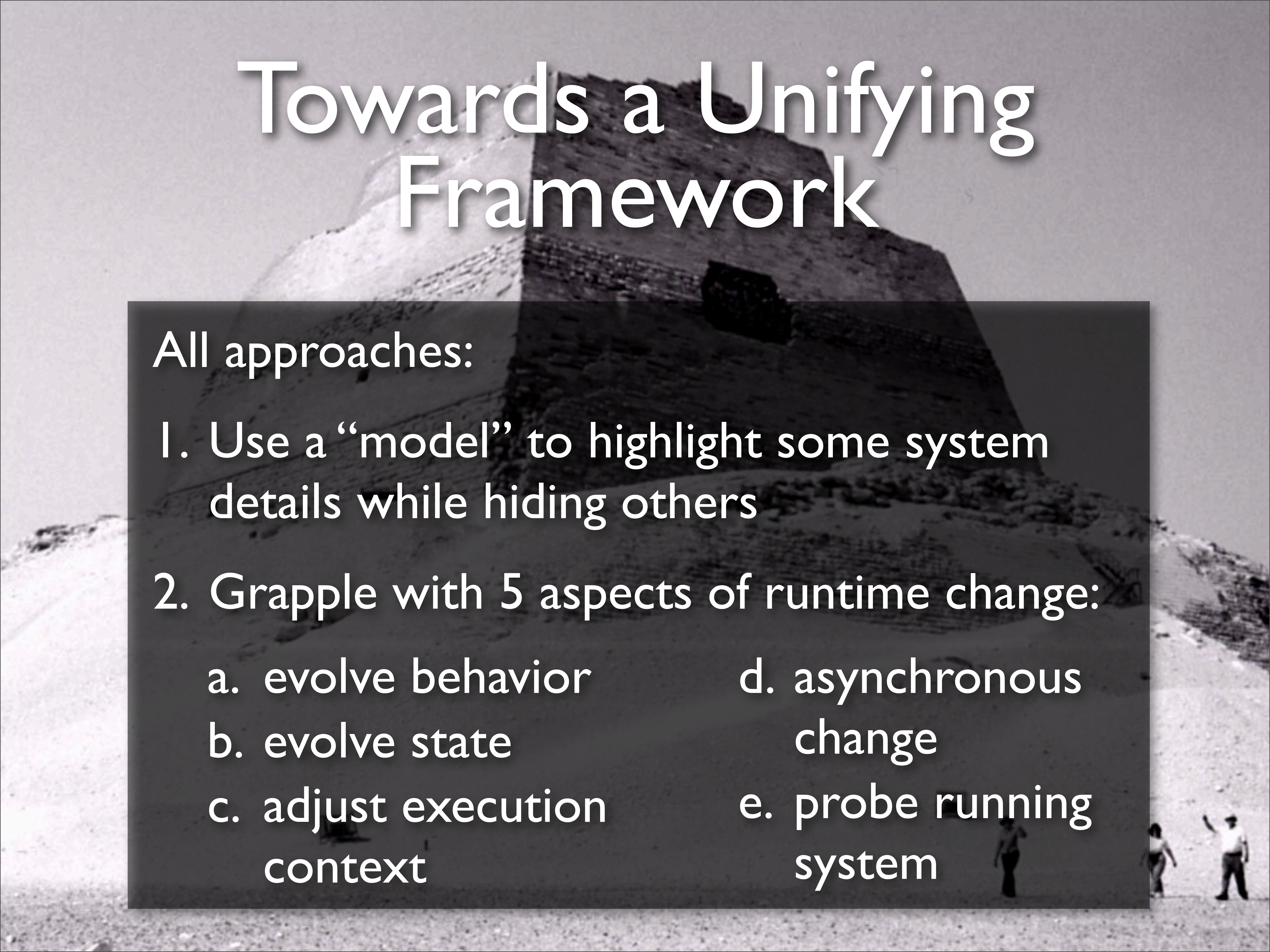
Towards a Unifying Framework

All approaches:

1. Use a “model” to highlight some system details while hiding others

2. Grapple with 5 aspects of runtime change:

   a. evolve behavior
   b. evolve state
   c. adjust execution context
   d. asynchronous change
   e. probe running system



A Look Back

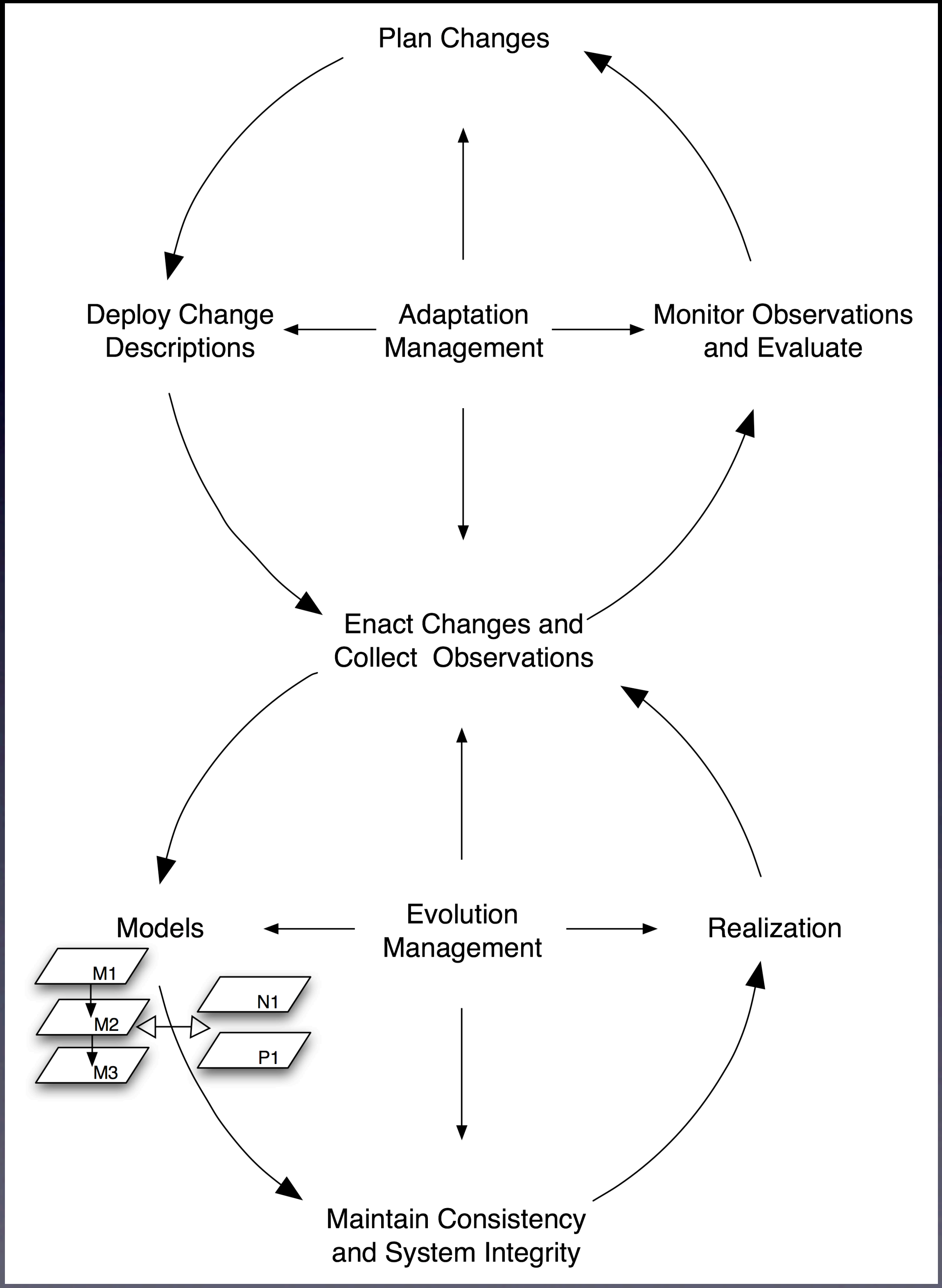
- What has happened in the past decade?
  - Dynamic adaptation models
  - Research projects
  - Open-source and commercial systems
  - Conferences, symposia, and workshops

Dynamic Adaptation Models I

- Prior to our ICSE 1998 paper
  - Style-based models: CHAM, graph-grammars
  - ADL-based models: Darwin, Dynamic Wright, Rapide
- Did not gain wide adoption
  - Lack of system-level facilities
  - Constrained notion of dynamism

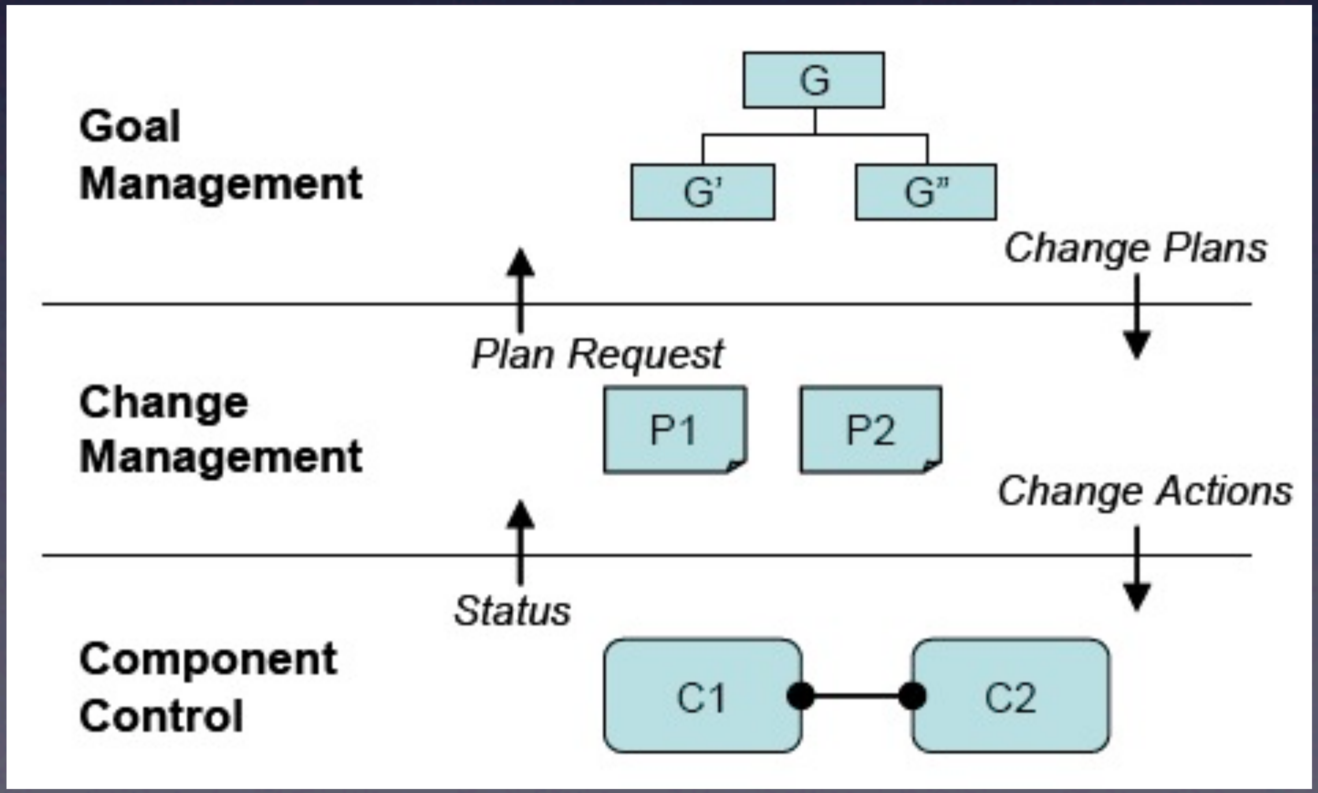
Dynamic Adaptation Models II

- Subsequent to our ICSE 1998 paper
  - "Figure 8" model: system adaptation driven by architecture


Plan Changes
Deploy Change Descriptions
Adaptation Management
Monitor Observations and Evaluate
Enact Changes and Collect Observations
Models
Evolution Management
Realization
M1
M2
M3
N1
P1
Maintain Consistency and System Integrity

Dynamic Adaptation Models III

- Rainbow: similar to “Figure 8”
- Self-managed systems: dynamic plan generation



Research Projects

- Aura: QoS-driven system reconfiguration
- MobiPads: QoS optimization via dynamic reconfiguration
- Siena: Client-, server-, and network-level dynamism
- Grid computing: Dynamic addition and removal of computing resources

Commercial Solutions

- Koala: predefined dynamic adaptations via options
- Skype
  - Promotion/demotion of nodes
  - P2P-based adaptations
- MapReduce: automatic data rerouting from failed to live nodes

Conferences/Symposia

- Dynamism as primary focus
- Dynamism as a means or by-product
- Dynamism in flagship SE conferences

Dynamism as Primary Focus

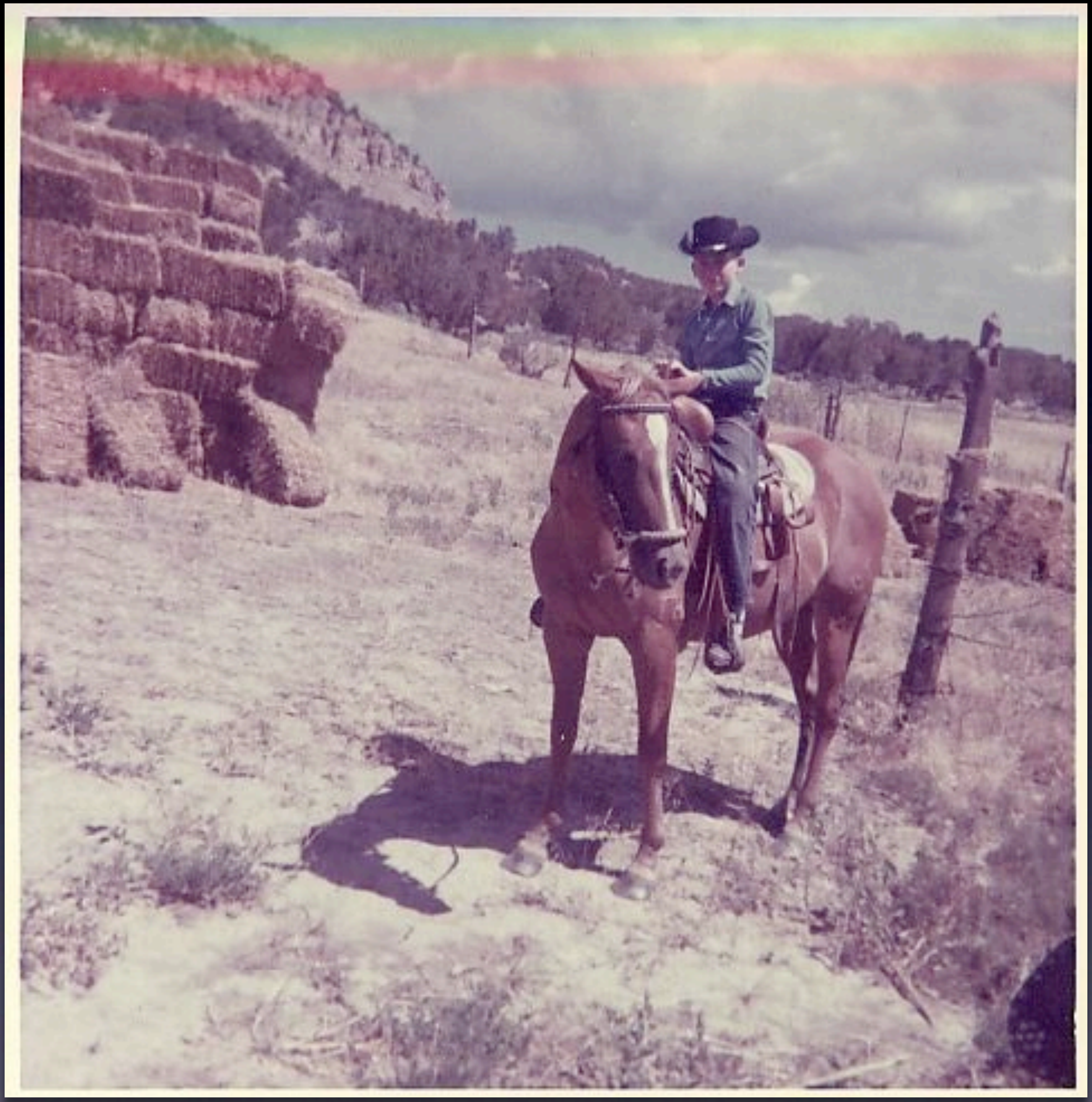
- ICAC
  - ACW
  - CHIAACS
- SEAMS
  - WOSS
  - DEAS
  - WADS
  - IWPSE
- Dagstuhl SESAS

Dynamism as By-Product

- MobiCom
- PerCom
- CD
- Middleware

Dynamism in SE Conferences

- What happened to dynamism at:
  - ICSE
  - FSE
  - ASE
- What about software architecture venues:
  - WICSA
  - ECSA
  - QoSA
  - CBSE



Promising Directions

- A simple message: if you want or need adaptable applications you can either:
  - Make no constraints on developers
    - ... and then work like crazy to try to obtain adaptation
  - Constrain development to make adaptation easier and predictable
- This should not be news: the message is *styles*

How Do You Make Adaptation Easier?

- Make the elements subject to change identifiable
- Make interaction controllable
- Provide for management of state

Lots of Successful Examples

- Pipe-and-filter
- Dynamic pipe-and-filter: Weaves
- Event-based systems: Field & pub-sub
- Event-based components and connectors: C2
- REST

Arch Style	Update Behavior	Update State	Update exec context	Asynchrony of change	Impl. probes
Pub-Sub	✓			✓	✓
Weaves	✓			✓	✓
C2	✓		✓	✓	✓
REST	✓	Data-State externalized	✓	✓	✓
CREST	✓	All computation state externalized	✓	✓	✓

Where Has Software Engineering Been WRT the Development of Effective Styles?

Not just for adaptivity, but other qualities too

UPOZORENJE !
ISPUŠTA SE VODA
IZ BAZENA
ATTENTION !
THE WATER IN THE
SWIMMING POOL IS
BEEING CHANGED

A Call to Action

- A science of design
- A science of realization
- A science of dynamic adaptation
- A science of domain-specific software engineering
- (Discovery-based research)

Questions?