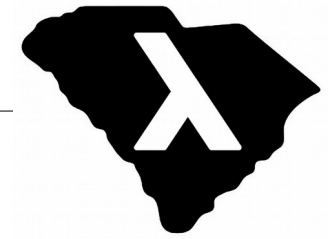
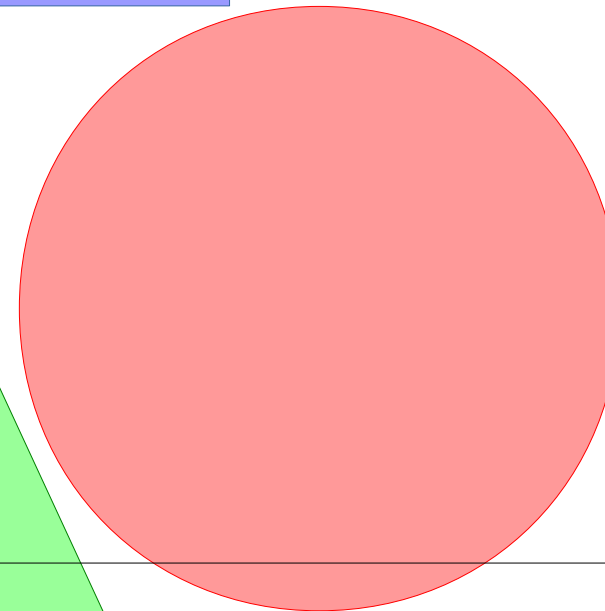
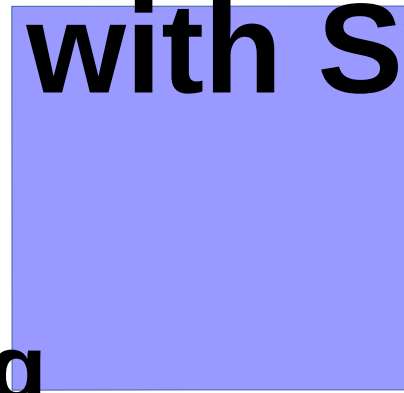
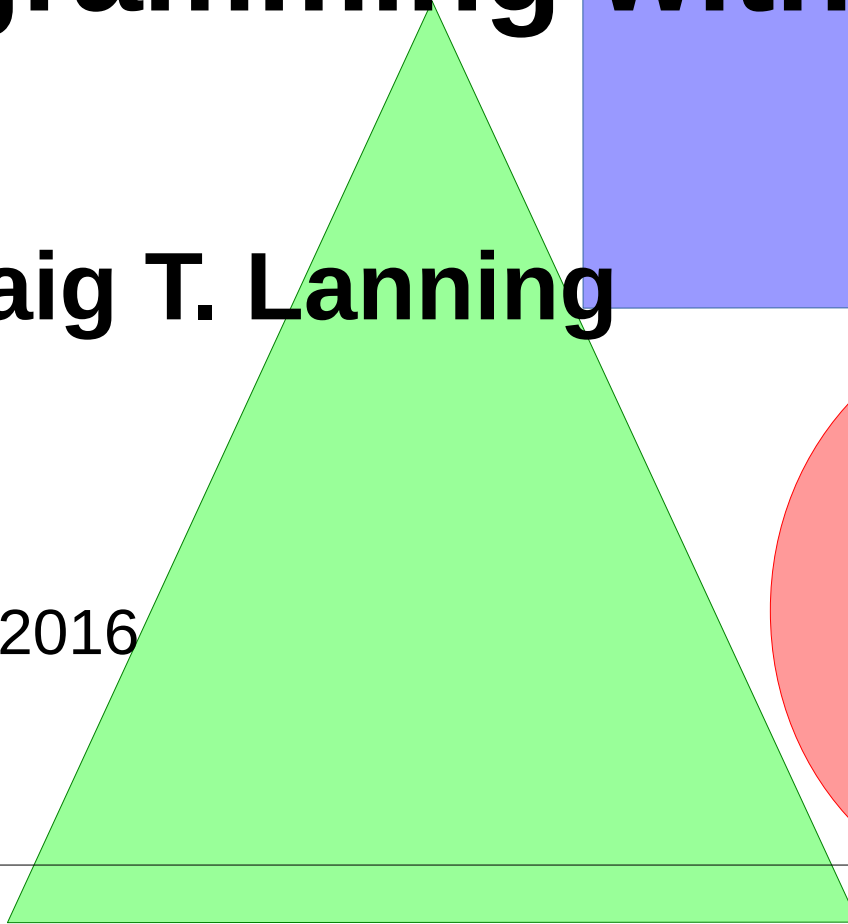


# Bare Metal Functional Programming with Symbolics

by Craig T. Lanning

May 17<sup>th</sup> 2016



# Symbolics History

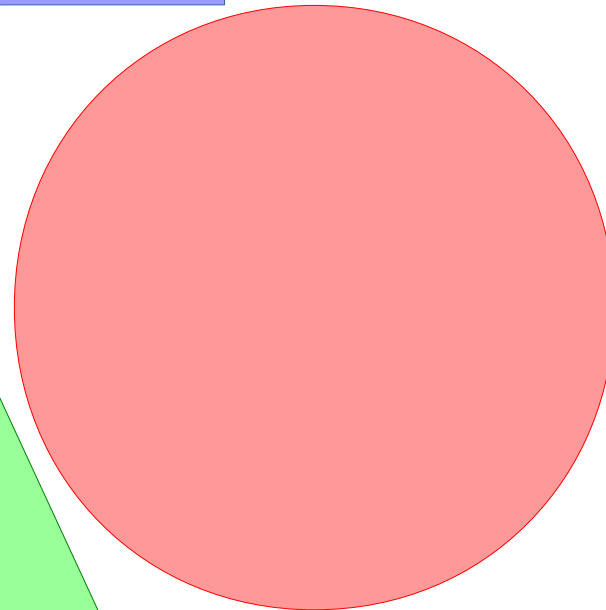
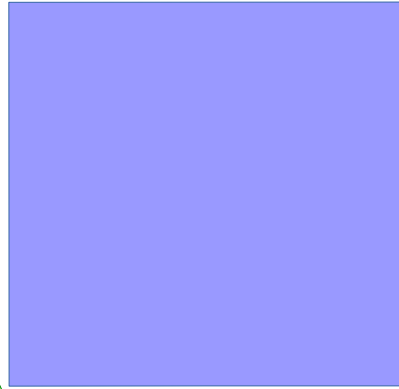
- Premiere Manufacturer of Lisp Machines
- Started in 1980 by PhD's from MIT
- First product, LM-2, was derived from the MIT CADDR
- Later came the 3600 series
- Finally the Ivory (Lisp-on-a-chip)
- Employees worked on CLIM Specification
  - Common Lisp Interface Manager
  - CLIM borrowed heavily from Dynamic Windows
- Employees worked on Common Lisp Standard

# PC vs. Symbolics in 1982

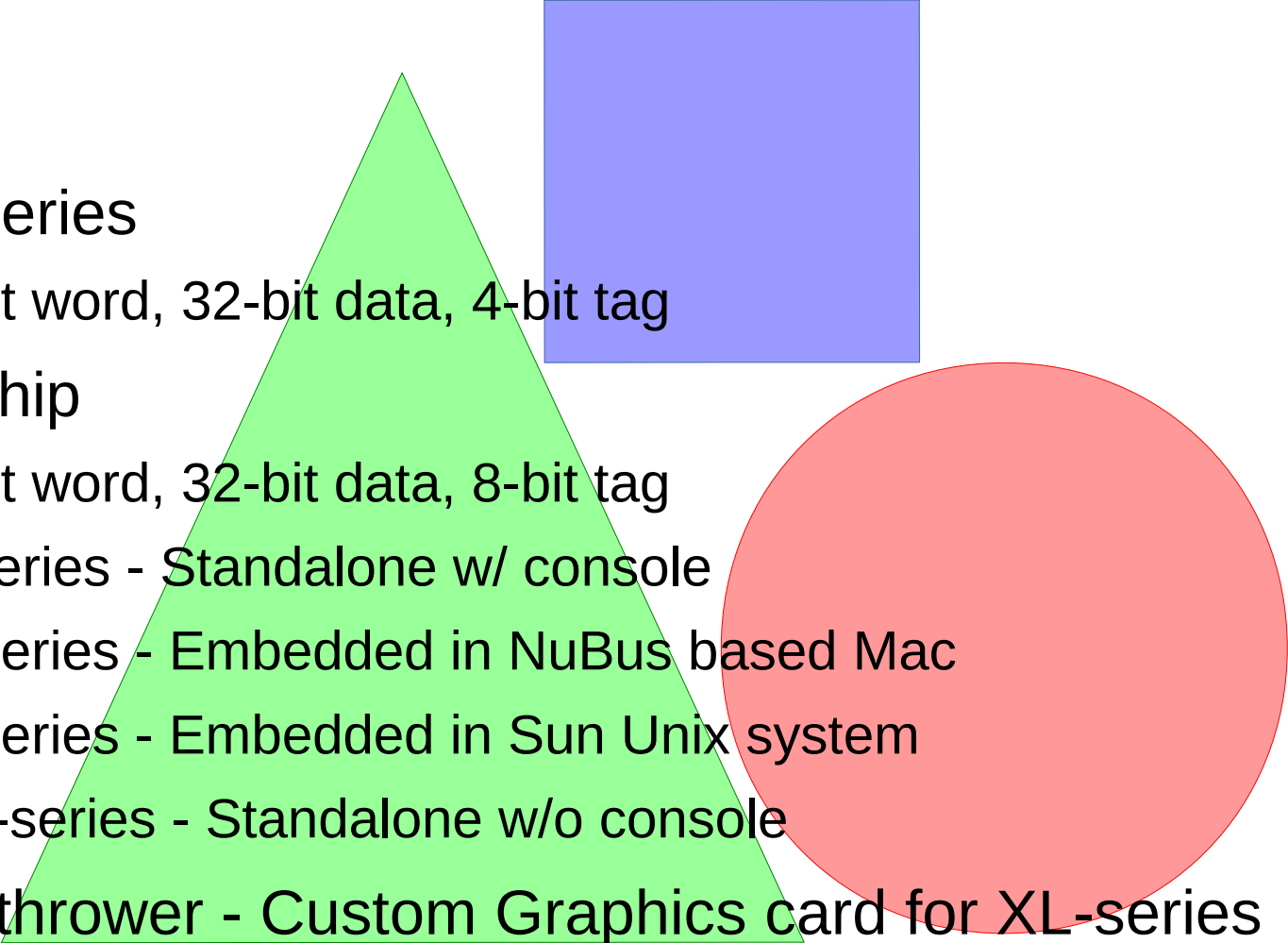
- IBM PC
  - CGA Display
    - 320x200 w/ 4 colors
    - 640x200 w/ 2 colors
  - Intel 8086 Processor
    - 16-bit word, 8-bit bus
    - Memory  $2^{20}$  bytes
      - 640K addressable
      - 256K RAM max
  - Audio: internal speaker
- Symbolics 3600
  - High-Res Bitmapped
    - 1100x900 w/ 256 colors
    - 1100x900 w/ 16M colors
  - Microcoded Processor
    - 36-bit word and bus
      - tagged memory
    - Memory  $2^{32}$  words
      - Fully virtual
  - Audio: 16-bit audio

# Architecture

- 3600 series Microcoded Processor
  - 36-bit word: 32-bit data, 4-bit tag
  - ESDI Disk
- Ivory Processor (Lisp-on-a-chip)
  - 40-bit word: 32-bit data, 8-bit tag
  - SCSI Disk and Tape storage
- Memory accessed by word not byte
- System consisted of two processors
  - the FEP (Front End Processor, Motorola 68000)
    - booted the machine
    - loaded microcode in 3600 series systems
    - managed file storage space
    - initialized the Lisp Processor
    - loaded the Lisp World
  - the Lisp Processor (3600 or Ivory)



# Hardware

- LM-2
  - 3600 series
    - 36-bit word, 32-bit data, 4-bit tag
  - Ivory chip
    - 40-bit word, 32-bit data, 8-bit tag
    - XL-series - Standalone w/ console
    - NX-series - Embedded in NuBus based Mac
    - UX-series - Embedded in Sun Unix system
    - NXP-series - Standalone w/o console
  - Framethrower - Custom Graphics card for XL-series
- 

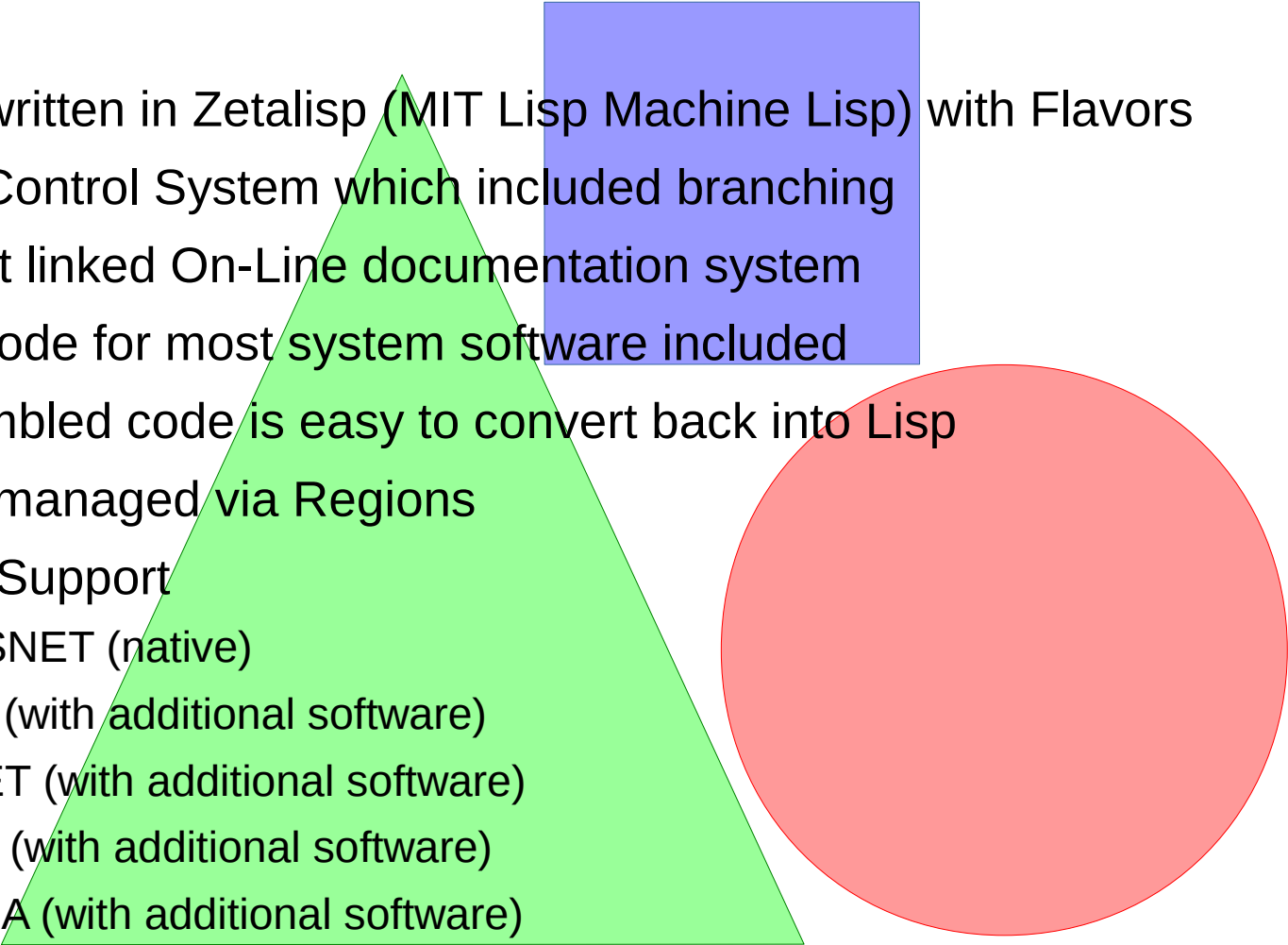
# Operating System

- Genera (v8.3)
  - Microcoded Processor
  - Ivory Processor (microprocessor)
- Open Genera (v2.0 - Genera 8.5)
  - Software only version of Genera
    - Required a 64-bit processor to run
    - Only way to get 32-bits of data and 8-bits of tag
  - Included almost all Layered Products
  - DEC Alpha was hardware platform

# Trivia

- Numerical Calculations faster than FORTRAN
- Machines are nearly impossible to crash
- Camio Appearance in movie "Real Genius"
- Used to develop Flocking Motion for CGI
  - See "Stanley & Stella in Breaking the Ice"

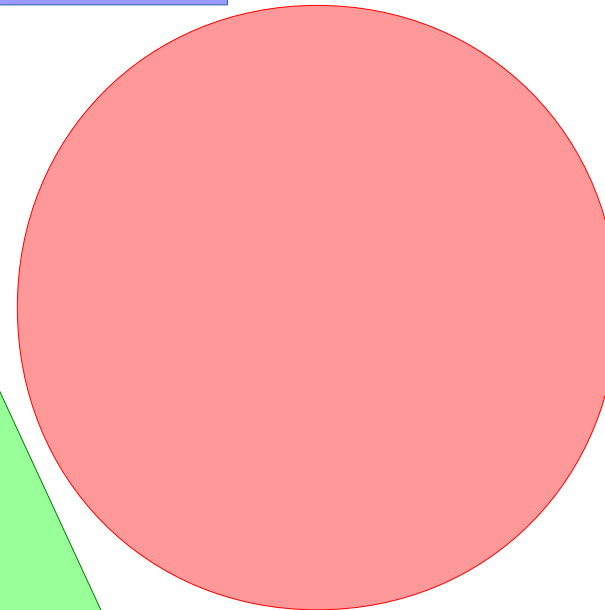
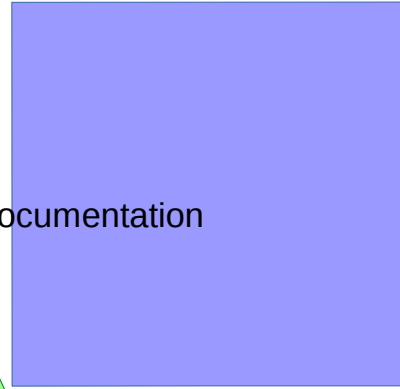
# System Features

- Genera written in Zetalisp (MIT Lisp Machine Lisp) with Flavors
  - Version Control System which included branching
  - Hypertext linked On-Line documentation system
  - Source code for most system software included
  - Disassembled code is easy to convert back into Lisp
  - Memory managed via Regions
  - Network Support
    - CHAOSNET (native)
    - TCP/IP (with additional software)
    - DECNET (with additional software)
    - NFS v2 (with additional software)
    - IBM SNA (with additional software)
- 



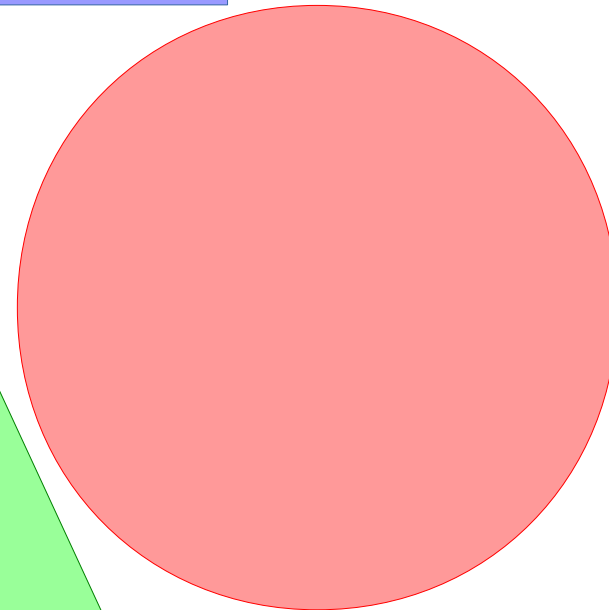
# Layered Software

- Concordia
  - Documentation system
  - Used to make the Symbolics online and printed documentation
- C Compiler (very slow)
- FORTRAN Compiler
- Prolog Compiler
- PASCAL Compiler
- Computer Modeling and Animation Software
  - S-Geometry, S-Render, S-Dynamics, S-Paint
  - Original implementation of Flocking Motion
  - Movie Short to demonstrate the Flocking Motion
    - Rendered on a farm of 3600 series machines
    - Stanley and Stella in *Breaking the Ice* (3 minutes)
    - Available on YouTube
- X11 Server
  - Used the reference X Server which was written in C
  - Excruciatingly slow



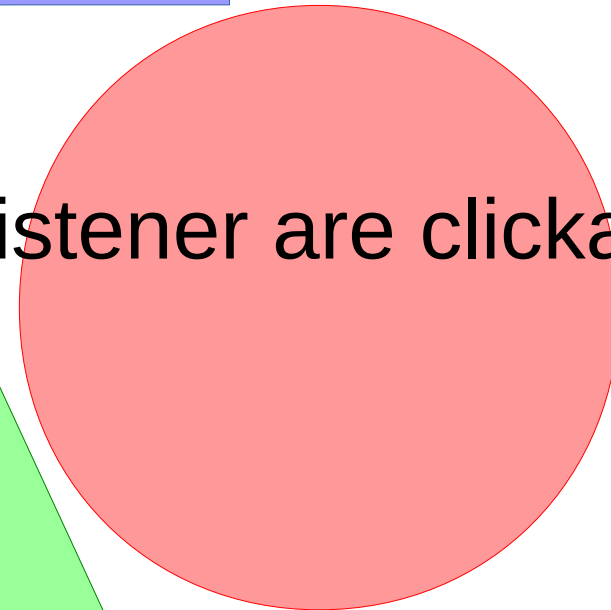
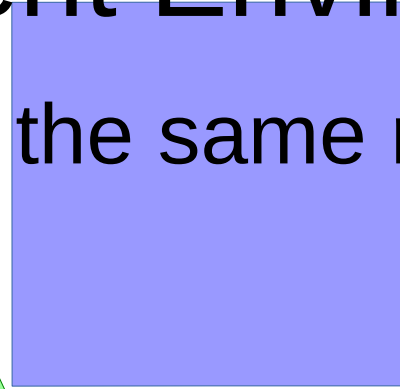
# Layered Software (cont.)

- Static - Object Oriented Database
- TCP/IP Server/Client
- NFS Server/Client
  - supports Version 1 and 2
  - only runs over UDP
- SNA Server/Client
- DECnet Server/Client
- Joshua - Expert System



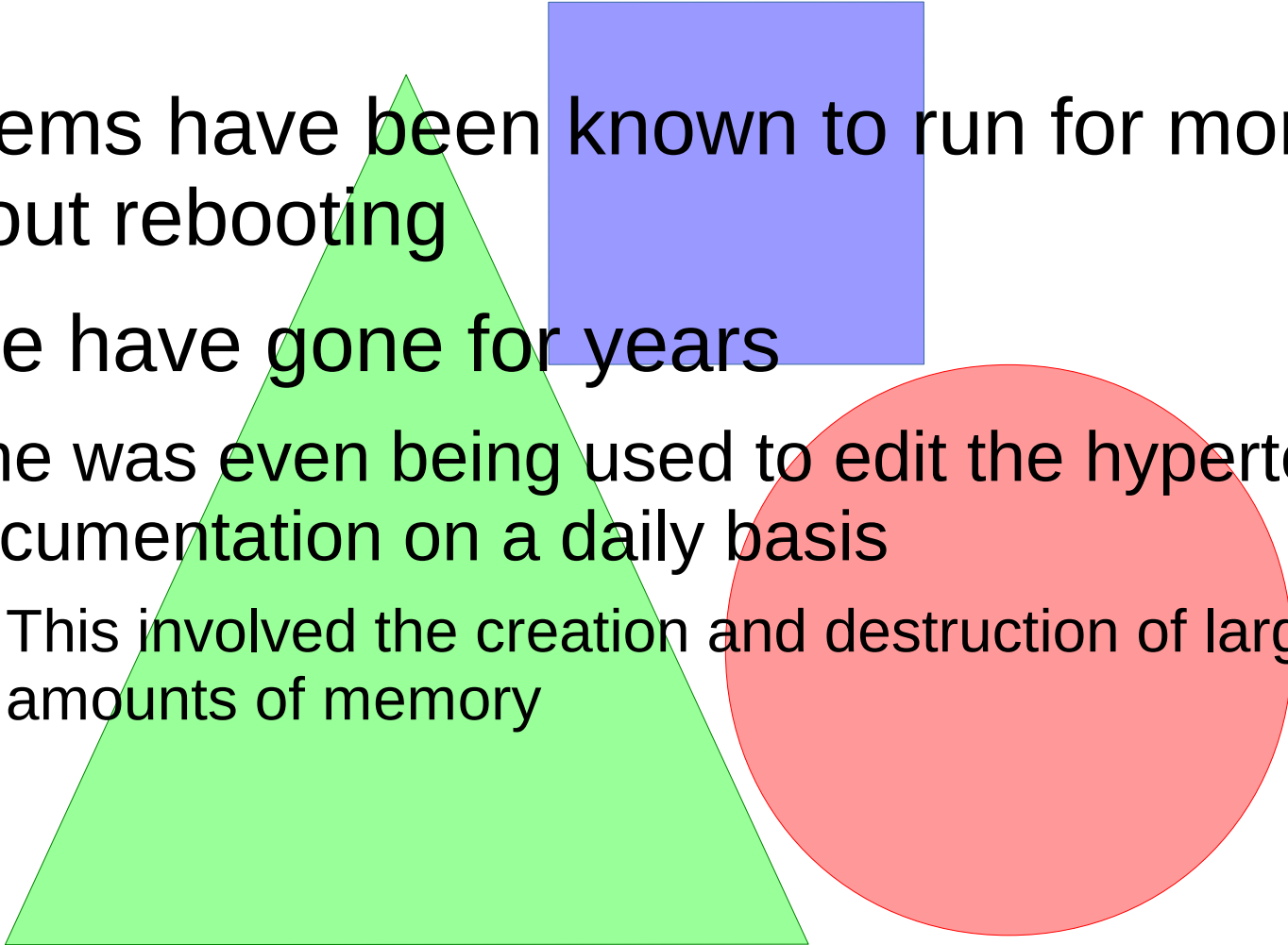
# Ultimate Integrated Development Environment

- Everything exists in the same memory space
  - Editor
  - Compiler
  - Debugger
- Objects printed in Lisp Listener are clickable



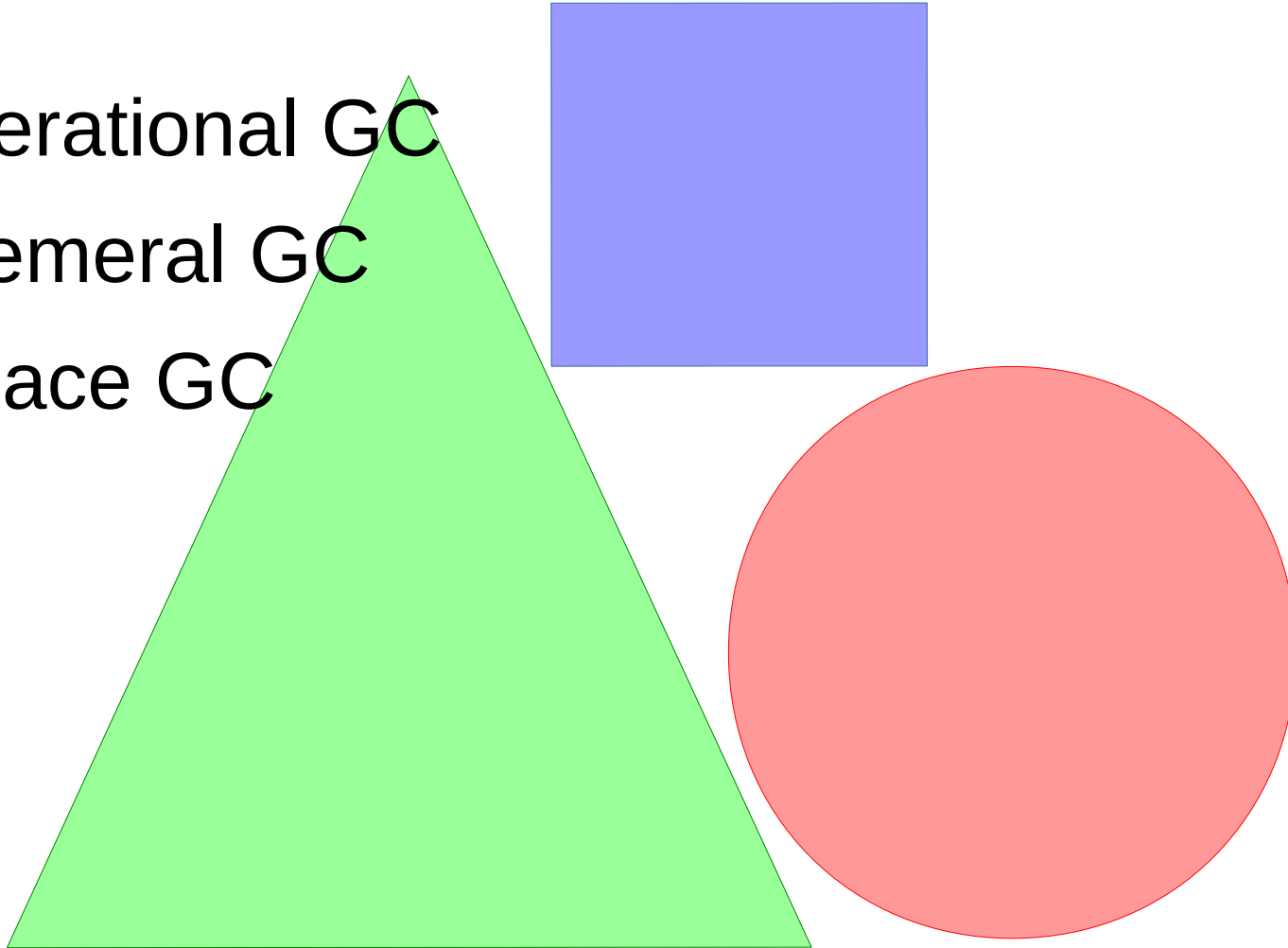
# Genera Crashproof

- Systems have been known to run for months without rebooting
- Some have gone for years
  - One was even being used to edit the hypertext documentation on a daily basis
    - This involved the creation and destruction of large amounts of memory



# Multimodal GC

- Generational GC
- Ephemeral GC
- In-Place GC



# This XL1201

- 4 MW of memory (20MB)
- 36 MB of virtual memory (180MB)
- Originally one of many being used by American Express
- Original New Price \$30,000
- Now it's a large paper weight

