Interactive Science and Math Simulations

Sam Reid
PhET Interactive Simulation
University of Colorado Boulder
• http://phet.colorado.edu
• Over 100 simulations, 50 languages
• Launched 2 million times/month for school
• Designed by content experts
• Interviewed with students and used in research
Simulations > New Sims

Build a Fraction
Gene Expression - The Basics
Plate Tectonics
Molecule Shapes: Basics
Fractions Intro
Fraction Matcher
Fluid Pressure and Flow
Sugar and Salt Solutions
Under Pressure
Normal Modes
Beer's Law Lab
Resonance
Concentration
Molarity
Energy Skate Park: Basics
Bending Light

Plus 108 more!
Port to tablets with HTML5

• PhET has 3 full time developers
• Pairing with 3 different companies
  – Quick Left (Boulder)
  – Bust Out (Minneapolis)
  – Competentum (Issaquah/Moscow)
• Prototype and search for approach:
  – Performant, cross platform, scalable, maintainable
Demos

• Masses & Springs, Flash → SVG
• Concentration, Java → Canvas (CAAT + CocoonJS)
# Choosing a Scene Graph

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<th>Name</th>
<th>Size (KB)</th>
<th>Lang.</th>
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<th>GitHub Forks</th>
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Scene Graph Wish List

- 1. Text + Shape + Image + Container
- 2. Bounds before rendering
- 3. Arbitrary nested transforms
- 4. multi-touch support
- 5. paint only dirty regions
- 6. animated transitions
- 7. cache nodes as buffered images
- 8. attach listeners to each node
- 9. clipping using a shape
- 10. constructive area geometry
- 11. ability to handle input events differently on mobile than on desktop (for interacting with small objects)
- 12. non-rectangular hit regions (like dragging a circle or irregular shape)
- 13. Good performance on Android, iOS, Desktop
- 14. Integration with 3d
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CAAT

- [http://www.ludei.com/tech/caat](http://www.ludei.com/tech/caat)
- Canvas, WebGL and DOM/CSS renderers
- Dirty rectangles—really helps on tablets
- Good at transforms, event listeners, layouts, etc.
Technologies

• require.js (modules)
• Grunt (build)
• Hammer.js (cross-platform multi-touch)
• CocoonJS (bundle for native)
• Underscore.js (util & functional library)
• jQuery (jQuery)
• CAAT/EaselJS/??? (scene graph)
Outstanding Questions

- Which scene graph library (if any)?
- DOM or canvas for widgets?
- Use a native wrapper for iOS + Android?
- How to support translations into 50 languages and share with Java versions?
- How to support downloadable/offline use
- Pinch to zoom?
- Should we make it easy to embed in client webpages?
- Scale up/down with window size + resolution?
- Log user activity for interviews and studies?
- How to ensure good performance on Android tablets?
Conclusion

• Complex problem
• We’re just beginning/still face many decisions.
• What will we regret X years down the road?
• I’d love to hear your recommendations
  – Visit me on twitter @sam6reid