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# GameRTS: A Regression Testing Framework for Video Games

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# Background

- Video games are popular and often frequently updated:
  - **More than 50%** web users play video games every week
  - Industrial game software can be updated **3** internal versions per day
  - Rapid updates of the game bring many **regression bugs**
- Regression testing is urgently required but costy:
  - Regression testing can take up **80%** of the testing budget
  - Regression Testing Selection (RTS) is needed for selecting the proper test cases


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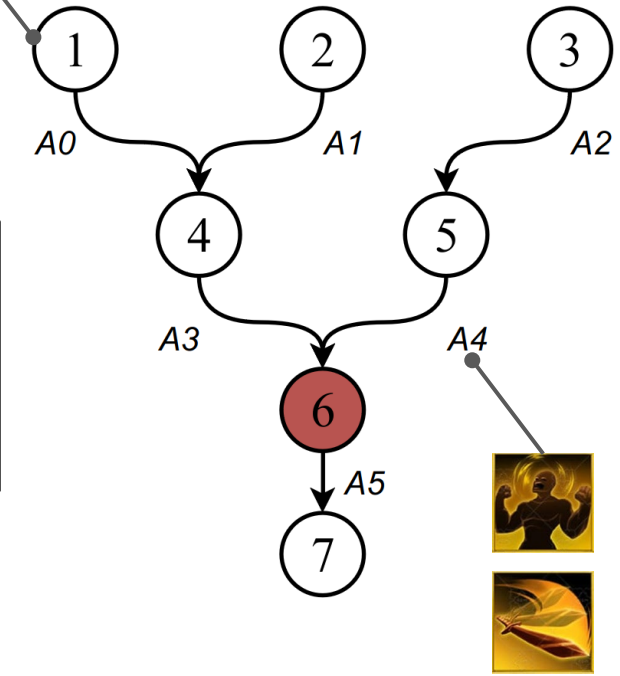
# Motivating Example

# Motivating Example

**State Transition Graph (STG)**




**All Test Cases**

- 1 -> 4 -> 6 -> 7
- 2 -> 4 -> 6 -> 7
- 3 -> 5 -> 6 -> 7

**[Change of State 6]**

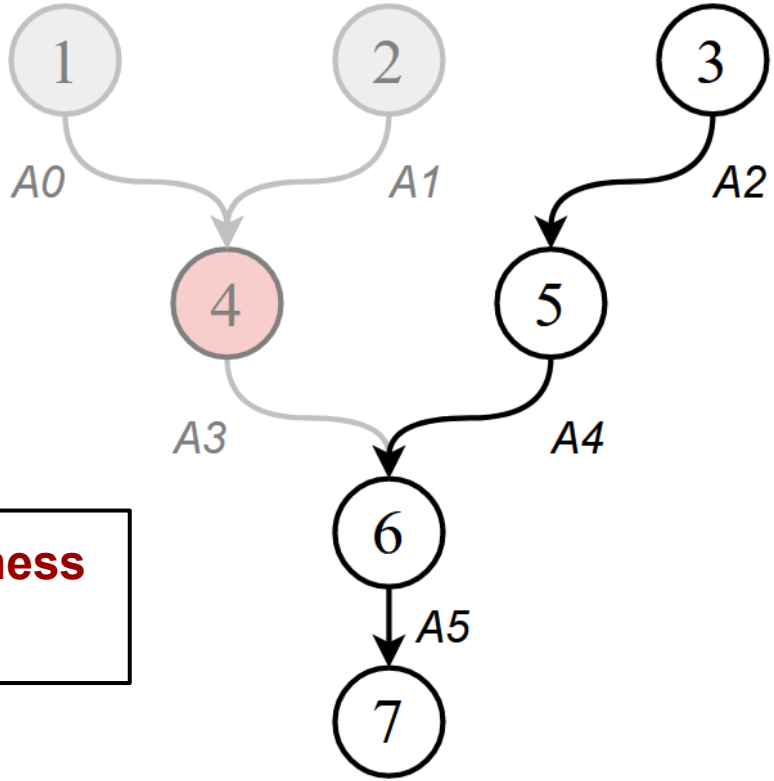
**Challenges**

- Select **ALL** test cases
- **LONG** execution time

# Current Testing in NetEase

Current Approaches for NetEase

- Scripts
- Manual testing




Game Companies Sacrificed the **Effectiveness** for Detecting Bugs for Testing **Efficiency**

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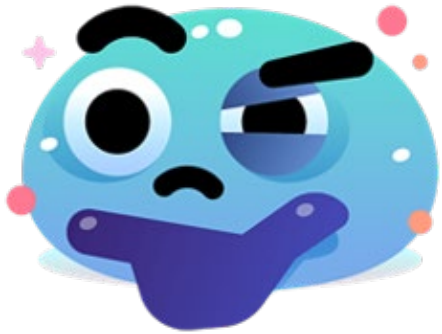

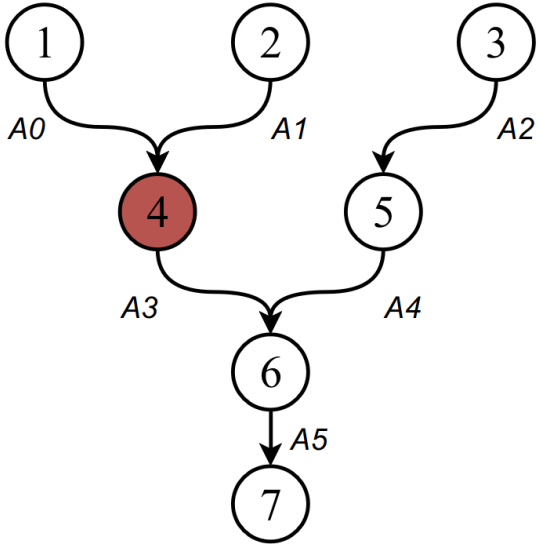


**How can we select the regression test cases of video games for both Effectiveness and Practicality?**

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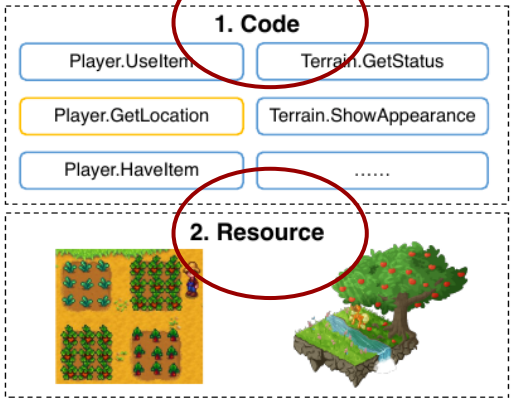
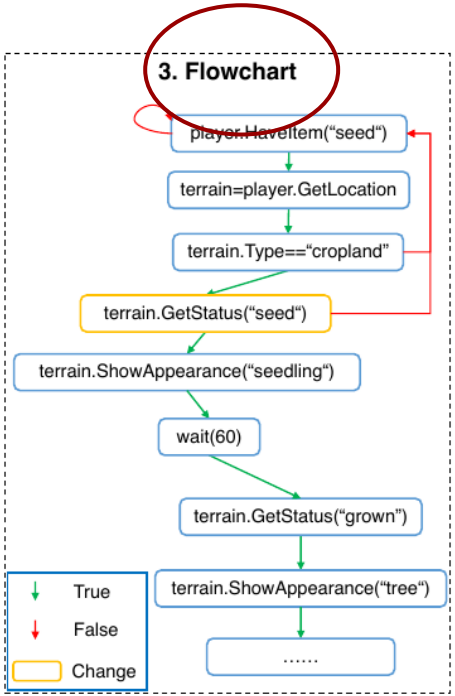
# Empirical Study of Video Game Bugs

| Step | Description |
|---|---|
| 1 | Accept the "plant" task from Tom. |
| 2 | Find and chat with Mike. |
| 3 | Get some seeds from Mike. |
| 4 | Go to find a cropland. |
| 5 | Sow the seeds and harvest apples. |
| 6 | Give apples to Tom. |




**Finding 1:**

**After analyzing 2763 bugs, we found the bugs are related to the changes of the 3 types of game files**

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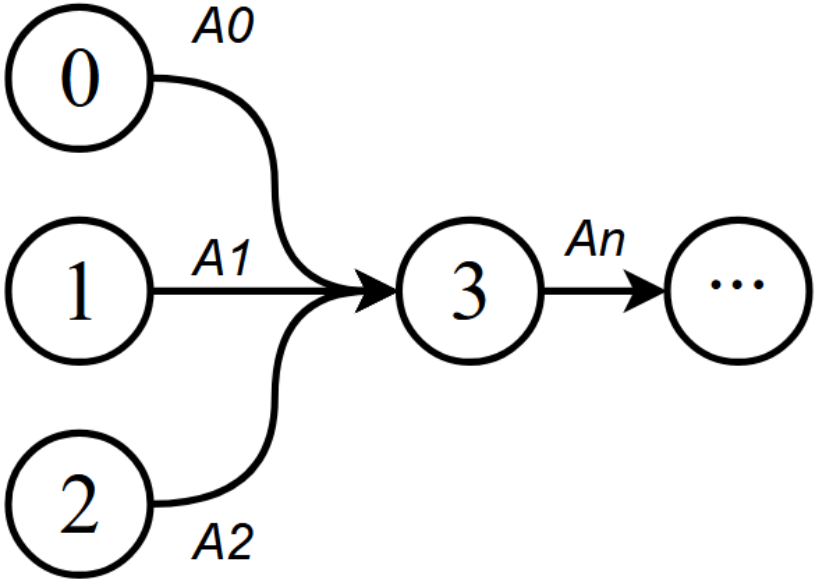
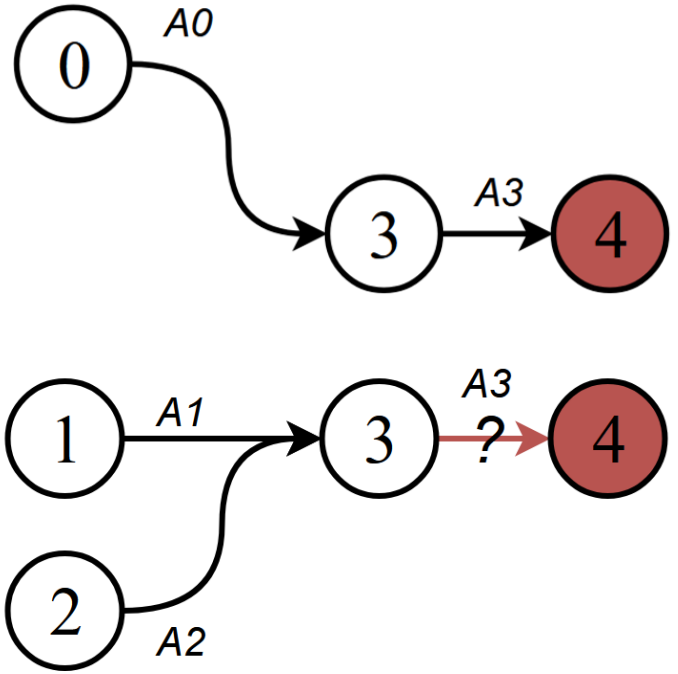
# Study of Game Context Sensitivity

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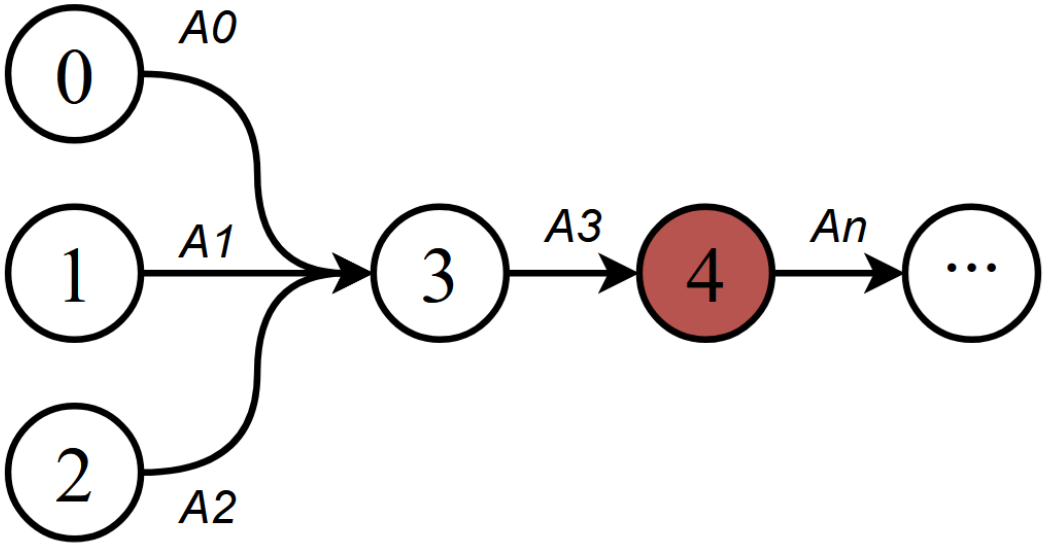
# Study of Game Context Sensitivity




**Findings 2:**
**From 6 industrial games, we found that games are usually context-insensitive**

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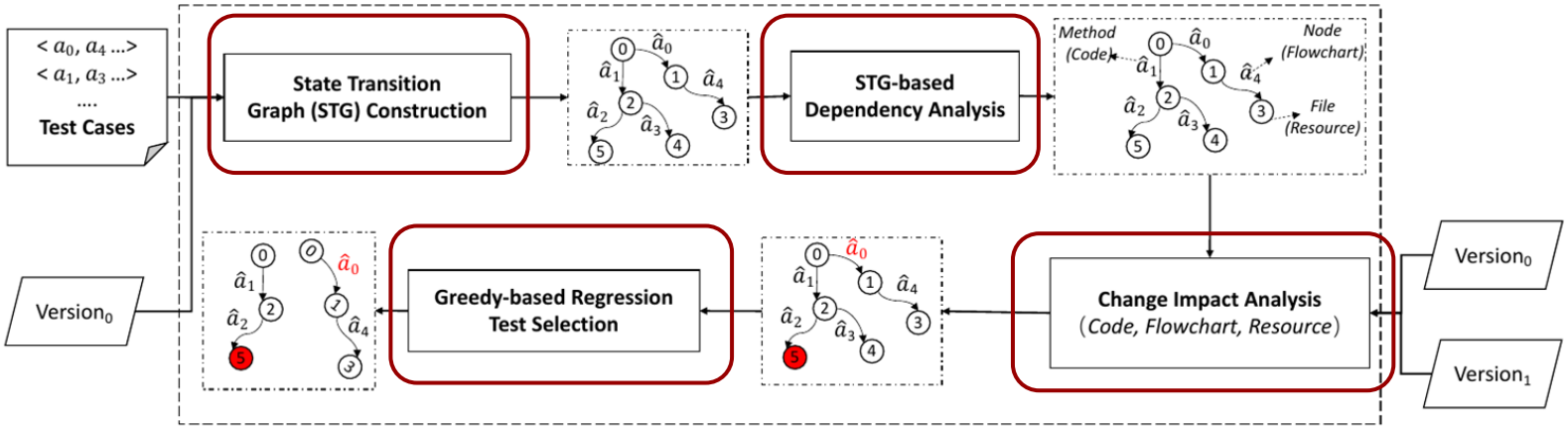
# Design of GameRTS




**Four Phases:**

1. **State Transition Graph (STG) Construction**
2. **STG-based Dependency Analysis**
3. **Change Impact Analysis**
4. **Regression Test Selection**

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# Evaluation

- **10 tasks** in **3 versions** of a popular video game named **Justice Online** (逆水寒), which has more than 30 millions of users
- **50** initial test cases
- Baselines
  - Running all the test cases
  - Running randomly selected test cases
  - Manual testing under 5 professional game testers

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# Evaluation - Effectiveness and Efficiency

- Bug Detection Ability and Costs

| ID | $V_0 \rightarrow V_1$ | | | | | | | | $V_1 \rightarrow V_2$ | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | *GameRTS* | | All | | Random | | Human | | *GameRTS* | | All | | Random | | Human | |
| | Time(m) | #Bug | Time(h) | #Bug | Time(m) | #Bug | Time(m) | #Bug | Time(m) | #Bug | Time(h) | #Bug | Time(m) | #Bug | Time(m) | #Bug |
| 1 | 14.8 | 2 | 15.1 | 2 | 14.4 | 0.8 | 17.2 | 2 | 15.6 | 1 | 17.2 | 1 | 14.6 | 1.0 | 18.4 | 0 |
| 2 | 10.1 | 3 | 18.5 | 3 | 10.7 | 1.0 | 11.8 | 0 | 10.0 | 3 | 19.5 | 3 | 13.3 | 1.3 | 10.0 | 0.8 |
| 3 | 10.0 | 3 | 15.6 | 3 | 15.5 | 1.8 | 8.6 | 0 | 9.6 | 1 | 17.9 | 1 | 15.3 | 0.0 | 11.9 | 0 |
| 4 | 10.0 | 1 | 6.4 | 1 | 15.4 | 1.0 | 9.7 | 0 | 10.0 | 1 | 9.5 | 1 | 17.1 | 1.0 | 8.8 | 0 |
| 5 | 10.0 | 2 | 8.0 | 2 | 19.0 | 0.0 | 15.6 | 0.6 | 10.1 | 2 | 12.3 | 2 | 21.0 | 0.0 | 14.8 | 0 |
| 6 | 9.4 | 1 | 5.7 | 1 | 15.8 | 1.0 | 11.3 | 0 | 10.0 | 1 | 6.5 | 1 | 20.4 | 0.0 | 10.6 | 0 |
| 7 | 10.9 | 1 | 7.5 | 1 | 14.9 | 0.0 | 8.4 | 0 | 9.7 | 2 | 8.5 | 2 | 15.5 | 0.5 | 10.1 | 0 |
| 8 | 5.8 | 1 | 12.8 | 1 | 15.2 | 0.0 | 4.9 | 0 | 6.8 | 0 | 9.7 | 0 | 18.4 | 0.3 | 5.9 | 0 |
| 9 | 10.0 | 1 | 5.6 | 1 | 20.4 | 0.5 | 15.1 | 0 | 10.0 | 1 | 6.3 | 1 | 20.3 | 1.0 | 14.8 | 0.6 |
| 10 | 10.2 | 1 | 7.5 | 1 | 20.8 | 0.0 | 15.0 | 0 | 10.3 | 0 | 12.9 | 0 | 20.8 | 0.0 | 15.2 | 0 |
| Total | 101.2 | 16 | 102.5 | 16 | 162.1 | 6.1 | 117.6 | 2.6 | 102.1 | 12 | 120.3 | 12 | 176.7 | 5.1 | 120.4 | 1.4 |

GameRTS achieves balance between practicality and safety, which detect **ALL** known regression bugs and greatly save the computational resources

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# Regression Bug Example

**Description:** The updated version introduced Quick Time Event (QTE) for increasing the difficulty

**Bug:** The check code adopts ***press_num* == *n***. When pressing the correct key more than n times, it will lead the game to stuck

**Repair:** Fix the conditional statement for ***press_num*** from **== *n*** to **> *n***

During our experiment, GameRTS detects **2** new bugs

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# Summary

- We propose **GameRTS**, a STG based regression testing selection framework specially for video games, which balanced the **efficiency** and **effectiveness**
- Depending on the testing budget and context characteristics of the games, **GameRTS** can adopt different policies for strategic test cases selection.
- Website: https://sites.google.com/view/gamerts

**Website**

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# Q & A

Presented by Jiongchi Yu (jcyu.2022@phdcs.smu.edu.sg)

**Website**

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