



EdgeDroid

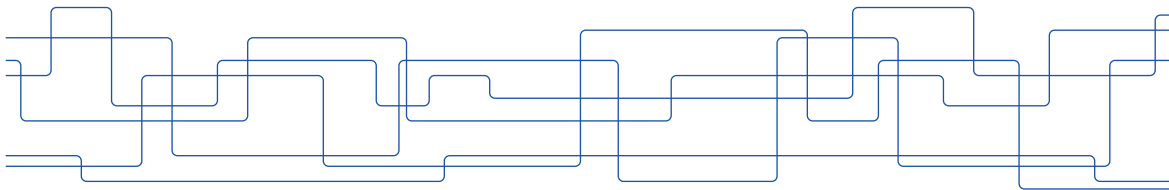
An Experimental Approach to Benchmarking Human-in-the-Loop Applications

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HotMobile'19 Session 5: February 28th 2019, Santa Cruz, CA







Sensory Input



Human-parseable
Feedback



Studying Human-in-the-Loop Applications

Need to understand and optimize these applications:

- ▶ How do they interact with each other?
- ▶ How do they interact with infrastructure?
- ▶ How do they scale?

With which methodology can we study these behaviors?



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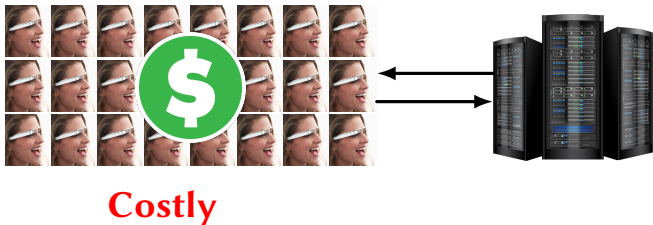


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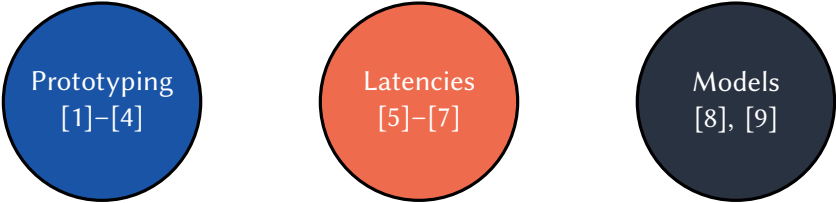
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Costly, poor repeatability

Previous & Related Work

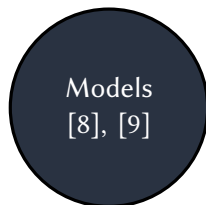
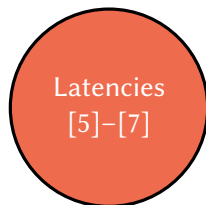
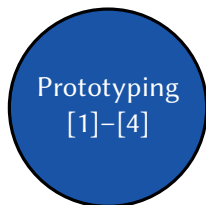


Prototyping
[1]–[4]

Latencies
[5]–[7]

Models
[8], [9]

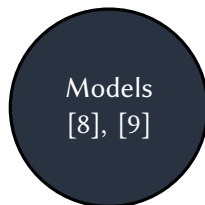
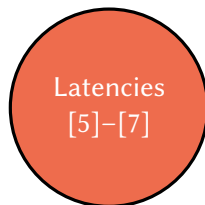
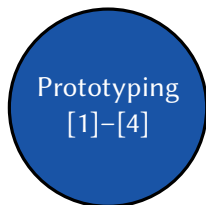
Previous & Related Work



Our Contributions

- ▶ A methodology for benchmarking human-in-the-loop applications.

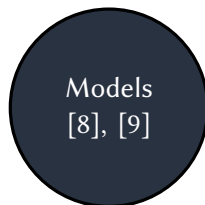
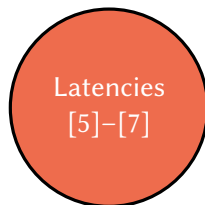
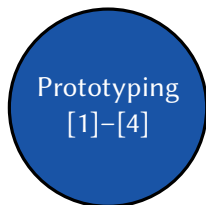
Previous & Related Work



Our Contributions

- ▶ A methodology for benchmarking human-in-the-loop applications.
- ▶ EdgeDroid: A benchmarking tool-suite.

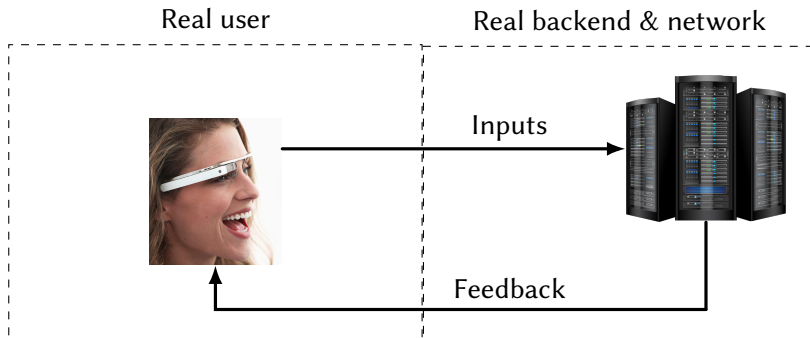
Previous & Related Work



Our Contributions

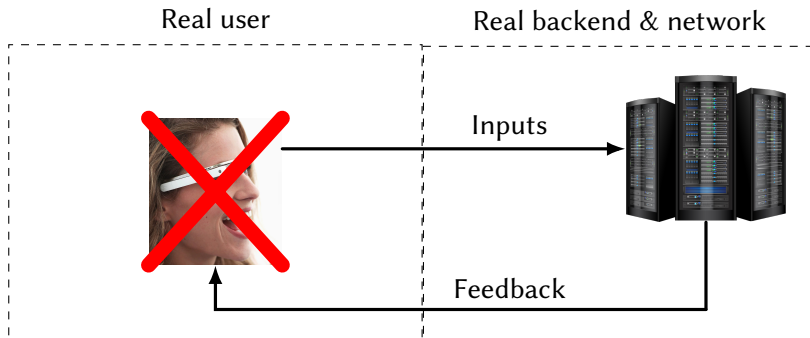
- ▶ A methodology for benchmarking human-in-the-loop applications.
- ▶ EdgeDroid: A benchmarking tool-suite.
- ▶ Experiments and measurements which show the effectiveness of the approach.

Approach



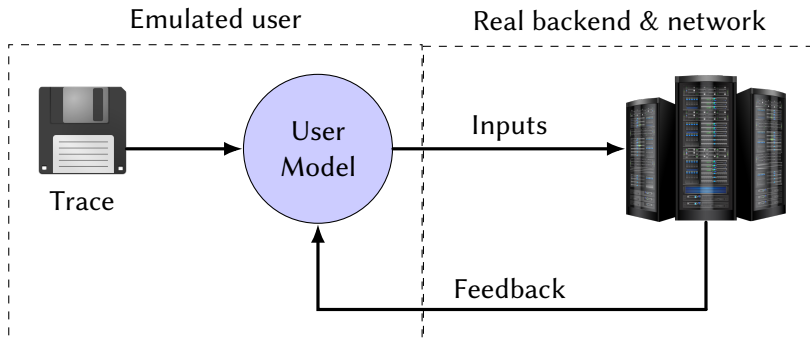
Benchmarking human-in-the-loop applications is HARD

Approach



What if we could do away with the human users?

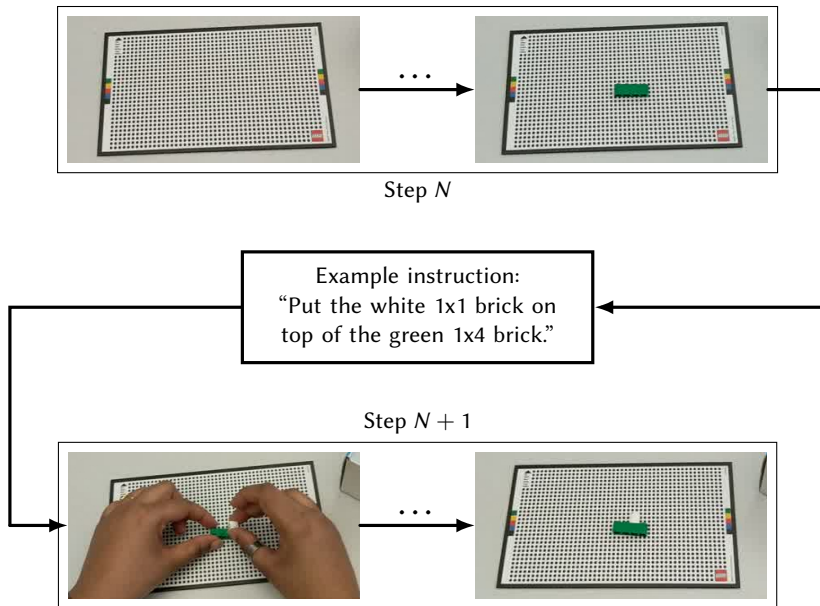
Approach



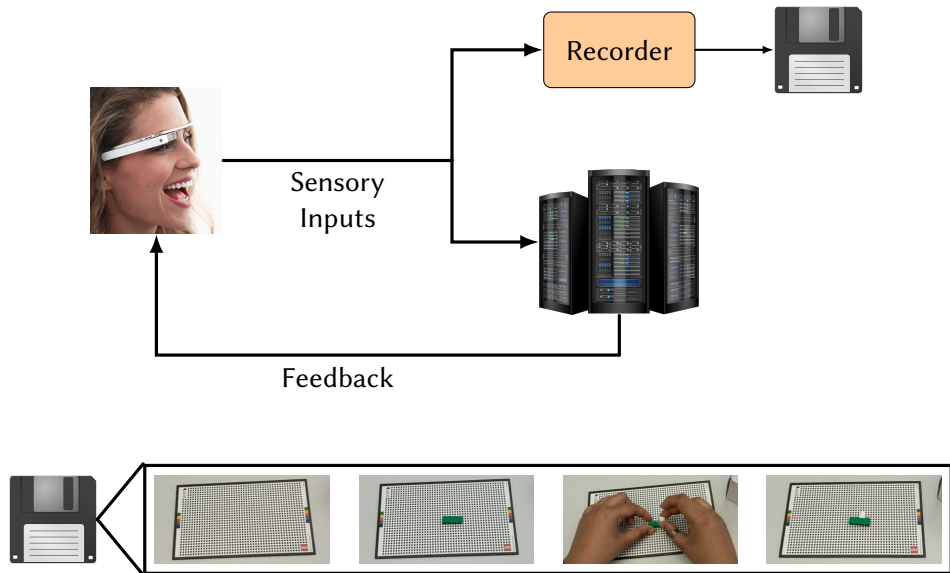
What if we could do away with the human users?

Repeatable, scalable!

Example: Task Guidance WCA, LEGO Assistant [1]



Tracing



Trace Replay

Non-trivial Challenge

- ▶ Changes in system responsiveness require adapting trace.
- ▶ System delays affect user behavior as well.

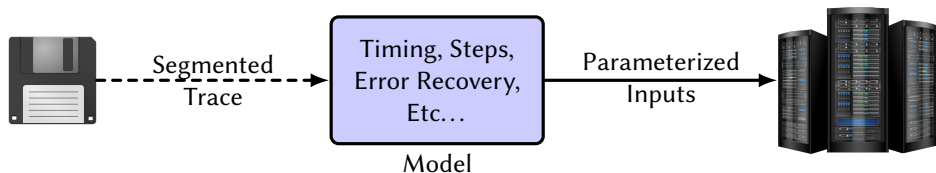
Trace Replay

Non-trivial Challenge

- ▶ Changes in system responsiveness require adapting trace.
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Our Approach

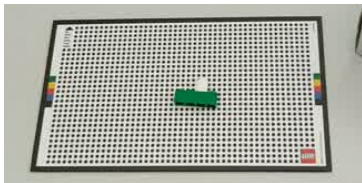
- ▶ Segment trace into logical “steps”.
- ▶ Control replay of steps through a parameterizable model of the task.
- ▶ Future work: replace with model of user behavior.



Key purpose:
Demonstrate utility of EdgeDroid.

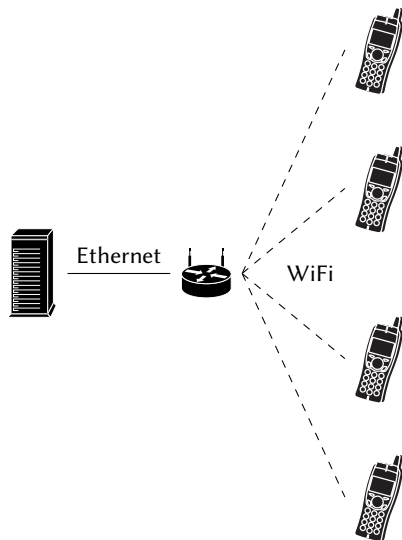
Evaluation: Setup

Application & Scenarios



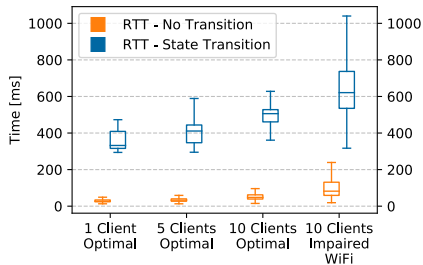
LEGO Assistant

- ▶ Three *optimal* scenarios with 1, 5 and 10 devices.
- ▶ Weakened wireless link with 10 devices.
- ▶ KPI: Round-Trip Time (RTT).

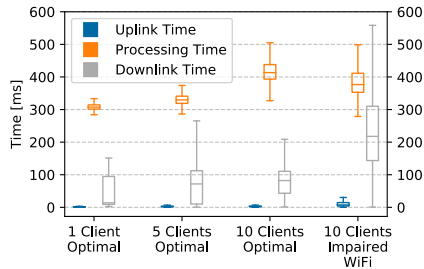


Use Cases

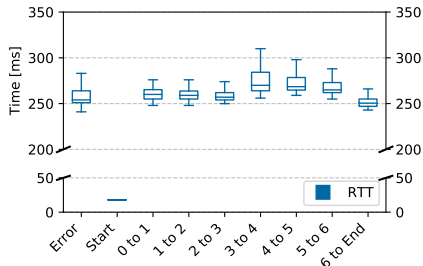
State change vs. no state change.



Times by pipeline segments.



RTT by task step.



Reference latency bounds for LEGO (Chen *et al.* [5])

Latency [ms]	Quality
< 600	Excellent
600 – 2700	Impaired
> 2700	Unusable

Conclusions

Future Work

- ▶ More accurate user model.
- ▶ Expand to other types of Applications.

Summary

- ▶ There's a need to study the scaling of Human-in-the-Loop applications.
 - ▶ This is difficult due to human users.
- ▶ We present a methodology + tool suite for benchmarking:
 - ▶ **EdgeDroid**
 - ▶ Trace based.
 - ▶ Model of human behavior.
- ▶ We present results which show the utility of EdgeDroid.



Thank you.

Contact

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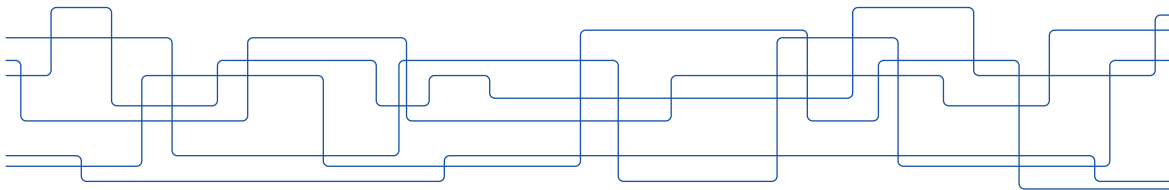
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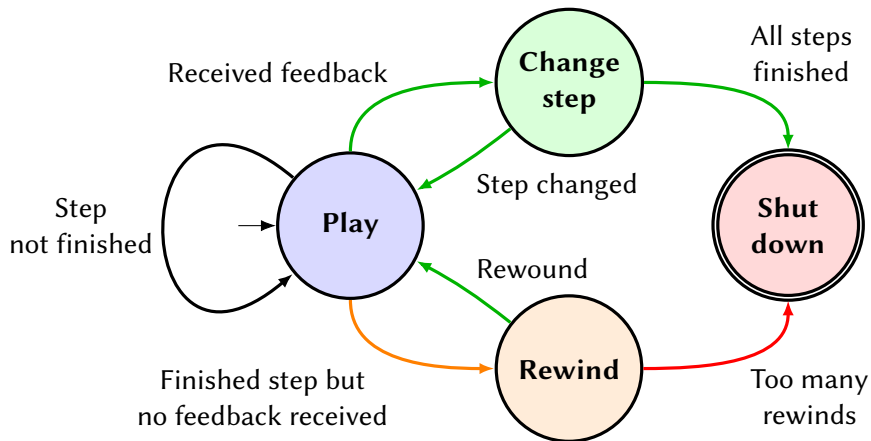


Requirements

- ▶ Generate realistic, high-dimensional, real-time inputs.
- ▶ Correctly and realistically react to feedback.
- ▶ KPI: Delays.

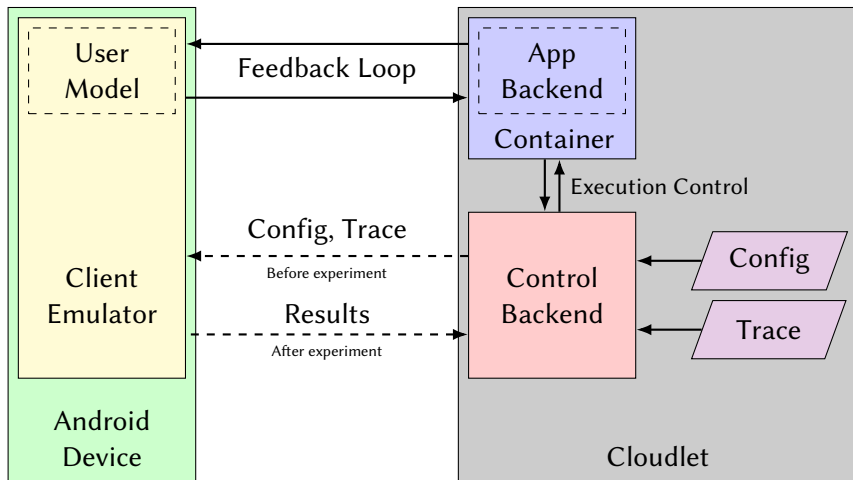
**Trace of pre-recorded inputs
& a model of user behavior**

User Model



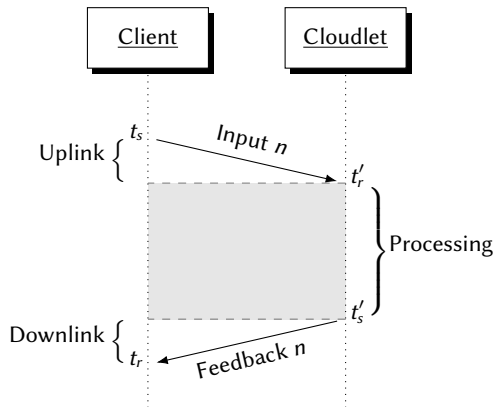
Future work: more elaborate models.

Implementation



 <https://github.com/molguin92/EdgeDroid>

Timestamping



Clocks are synchronized previous to the experiment.

Timestamps at key points to obtain:

$$\Delta T_{\text{up}} = t'_r - t_s \quad (1)$$

$$\Delta T_{\text{proc}} = t'_s - t'_r \quad (2)$$

$$\Delta T_{\text{down}} = t_r - t'_s \quad (3)$$

$$\Delta T_{\text{total}} = \Delta T_{\text{up}} + \Delta T_{\text{proc}} + \Delta T_{\text{down}} = t_r - t_s \quad (4)$$

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