



USER EXPERIENCES ON NETWORK TESTBEDS

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Testbeds: Opportunities and Challenges

- Many network testbeds: Cloudlab, Chameleon, Deterlab, COSMOS
 - Some include general compute nodes
 - Some are specialized: SCADA, IoT, smart drones, etc.
- Opportunities:
 - Provide realistic platforms for research evaluation
 - Engage students, improve knowledge retention in classes
 - Provide useful skills for job search
- Challenges:
 - New environment, new principles, steep learning curve
 - Requires user initiative and individual learning
 - Limited budget for testbed staff may impact user support

Research Questions

- Do users encounter obstacles when using testbeds?
 - Which ones? How serious?
 - Do all users have similar experiences?
 - Age, gender
 - Type of use (research vs class)
 - Prior experience and skills
 - Testbed
- How to prioritize interventions?
 - Many possible interventions, which ones are the best?
 - Many obstacles, which ones must be solved first?

Research Methodology

- Two user studies:
 - Disseminated broadly, but limited num. of volunteers
 - Reviewed and approved by our IRB
- Designed and ran the *interview study*
 - Users' experiences when using tbeds in classes
 - Open-ended, minimally guided
 - 13 participants, repeated answers
 - 2 testbeds: Deterlab and EDUrange
- Used these findings to design and run the *online study*
 - Users' experiences when using tbeds in classes or research
 - Guided (multiple choice) with a few open-ended questions
 - 69 participants, repeated answers
 - Multiple testbeds

Limitations

- Volunteer bias
 - Participants who had a good experience will volunteer
 - Focused on current users, not on potential or absent users

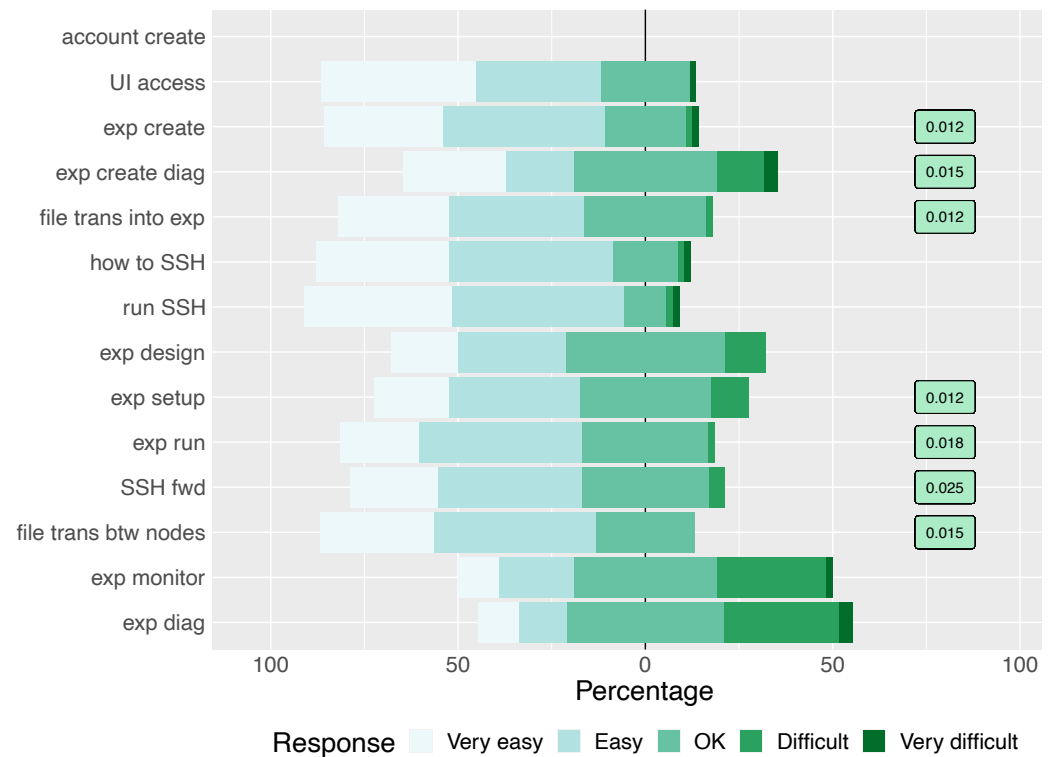
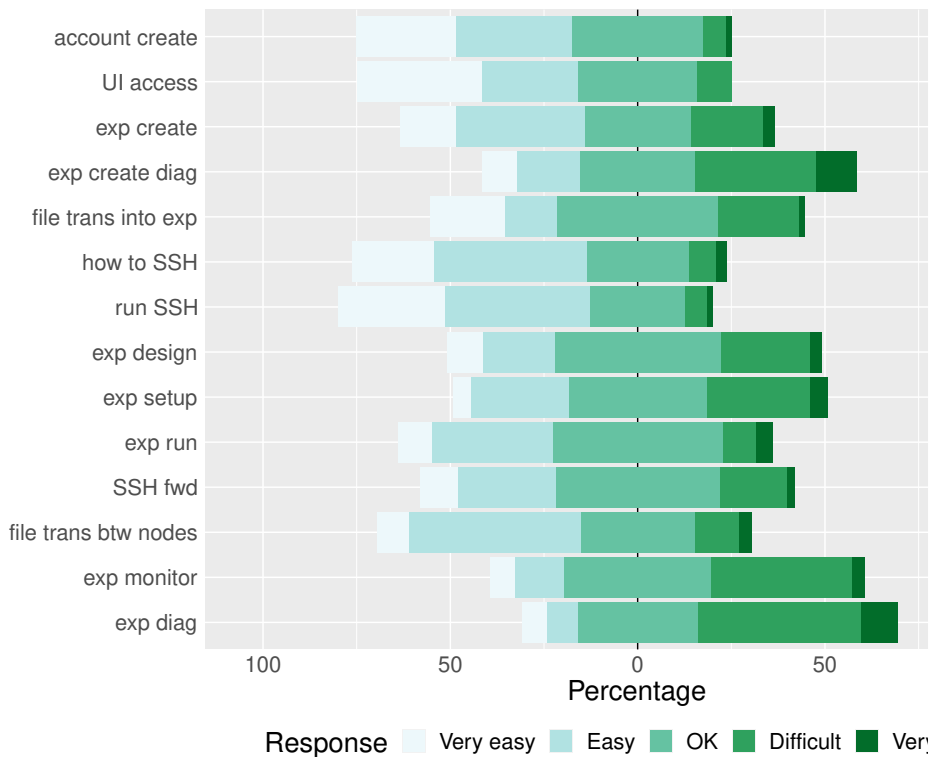
- Small and non-diverse user population

- From a small number of tbeds
- Most are male (76%), and used one testbed (66%)
- Most rated SSH and Linux experience as 3+ on 1-5 scale (80-85%)
- Good mix of class and research users (72%/58%)
- Good mix of novice vs experienced users (62%/38%)

Testbed	Interview	Online
Deterlab	12 (92%)	53 (76%)
EDURange	2 (15%)	0
Emulab/Cloudlab	0	18 (26%)
Chameleon	0	8 (11%)
Other	0	18 (26%)

Difficult: Design, Diagnostics and Monitoring

- Asked to rate difficulty of *early* and *recent* experiences
- Other activities are either easy or improve quickly

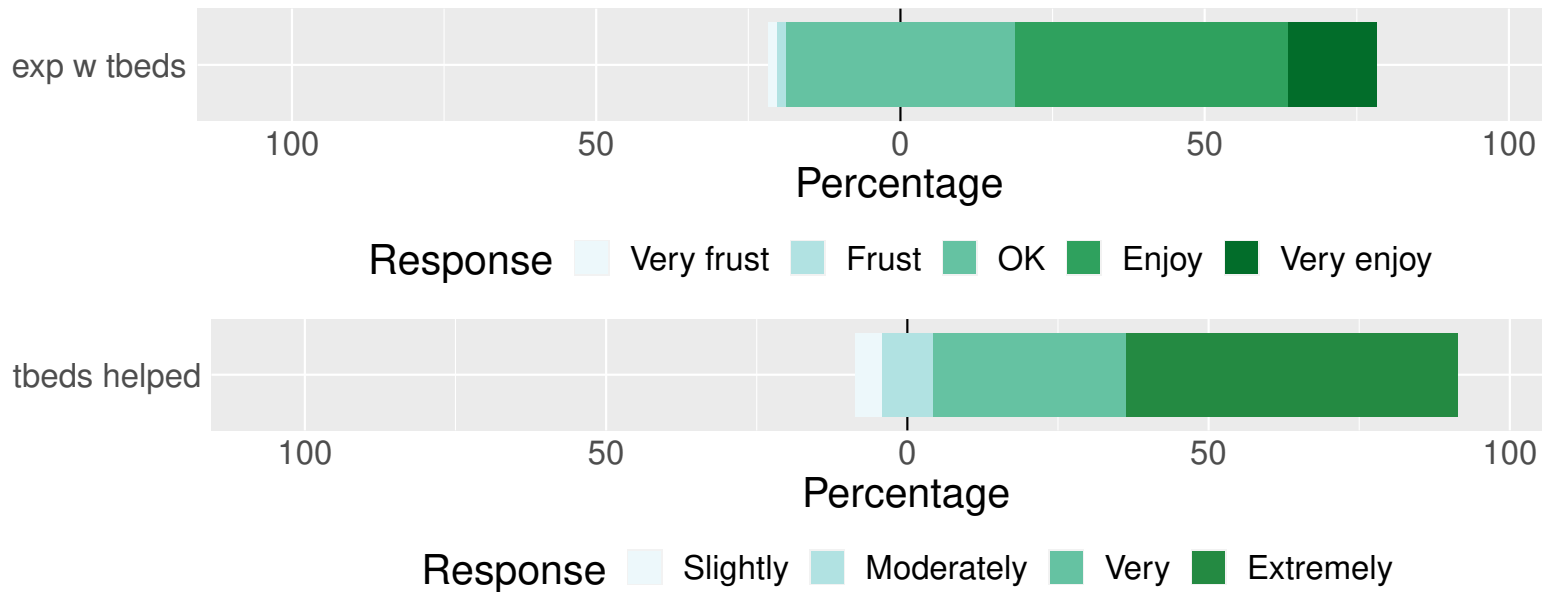


Few Other Factors of Influence

- A few differences between class and research users
 - Experiment setup and running are harder for research users due to higher difficulty of tasks
- SSH and Linux experiences help
 - Only for early experiences with understanding and running SSH, SSH forwarding, and transferring files between nodes
- No difference between testbeds
 - Similar early and recent experiences
- No difference wrt length of experience
 - Improvement happens quickly on easy tasks and does not happen on difficult tasks

Users Appreciate Testbeds

- Testbed staff is helpful and responsive (90-95%)
- Overall positive experience with testbeds
- Overall testbeds are very helpful for learning



Obstacles and Interventions

- **Orientalional** – learning new environment
 - Early struggle, but quickly overcome
 - Users appreciate learning new skills and feel empowered
 - Better documentation/UI can help
- **Implementational** – tbed architecture and focus
 - No support for experiment setup and running
 - Poor support for mental and physical context switch
 - Clean slate design is a burden
 - Better targeted support for design, setup and running (new backend and frontend functionalities)
- **Domain-specific** – testbed and research domain specif.
 - Provide basic tools for monitoring and diagnostics
 - Empower groups to develop and share domain-spec. tools

Conclusions

- Testbeds help users' learning but present some obstacles
 - Most obstacles are overcome quickly by users
 - Some obstacles remain around deeper functionalities
- We need higher investment into testbed tools and environments to tackle deeper problems
 - Akin to scientific experimentation domain
- Users appreciate testbeds and testbed staff
- Next study – adoption:
 - What influences the choice of researchers and teachers to use or not use testbeds
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