

Demo: FLaaS - Enabling Practical Federated Learning on Mobile Environments Telefónica Kleomenis Katevas<sup>\*1</sup>, Diego Perino<sup>2</sup>, Nicolas Kourtellis<sup>2</sup> <sup>1</sup>Brave Software, London UK; <sup>2</sup>Telefonica Research Barcelona, Spain DESIGN CHALLENGES ENVISIONED USE CASES 1. Easy to use by App designers & users Edge computing node 2<sup>nd</sup> use case: 3<sup>rd</sup> use case: 1<sup>st</sup> use case: 2. Multi-use case coverage FLaaS AL/ML modules Individual apps for Collaborative similar Collaborative, but Learned ML parameters 3. On-device ML training MI global model orthogonal apps for own ML problem apps for same ML ML results & inferences 3a. Single-app FL modeling new ML problem Personal data + command flows Movistar problem 3b. Joint-app FL modeling Uber+Spotify Spotify Instagram+Facebook 4. Secure & private ML training 3<sup>rd</sup>-narty service •GMaps+Spotify YouTube+Netflix Instagram 5. Production ready SYSTEM ARCHITECTURE CLIENT DEVICE MODULES ADMIN INTERFACE On-boarded **FLaaS** Customer App uthenticat Inter-App Comm/on Inter-App Comm/oi **Client Devices \$**/\$ Project Notification Backend Comm/on -Apple Push **Firebase Cloud** On-Device Training On-Device Training Service Provide Local Samples Notification Messaging Sample roday roday Device Status [-----Model cal ML Mode Policy Enforcement Reporter Policy Enforcement App Developer **†**6a Notification Andreas Andreas Andreas Andreas Aggregator • Notification Service Data Store Data Store Device \* MI Mode dennes a Model Scheduler Load Balancer App 1 Aggregator FI aaS I ib Global FLaaS Lib 9ŀ 8a. cation App X FLaaS Local: Web Interface FLaaS Library: FLaaS **REST API** App 2 Comms with Server Local Comms with FLaaS Local Device Front-end Database Bal **8**0 нттря Workers Comms with Apps Comms with App p App 3 Con Notifications Data Access Policy ٠ Model Aggregation On-device ML training Admin Interface FLaaS Server **Client Device**  Authentication **USER STATS & FEEDBACK REAL USER STUDY DESIGN ON-DEVICE ML-TRAINING COST** MODEL UTILITY IN THE WILD loint Samples Model **Device Specification**  144 unique users, 5 EU countries **Device Availability for ML tasks:** 0.6 • 4 weeks long (2-week windows/user) 94-99% of devices available/day Pixel 3a (P3a) Octa-core (2x2.0 & 6x1.7 GHz), 4GB RAM 0.5 Pixel 4 (P4) Octa-core (1x2.84, 3x2.42 & 4x1.78 GHz), 4GB RAM • 116 Android models, 15 manufacturers 37-82% of devices available/hour Ç 0.4 Pixel 5 (P5) Octa-core (1x2.4, 1x2.2 & 6x1.8 GHz), 8GB RAM Samsung(44%),Xiaomi(24%),Huawei(12%) **Impact on Phone Performance:** ACCU ACCU CPU usage(%) Demographics: 90.8% users: no change Duration(sec) Power Discharge (mAh) est 0.2 • 61% male : 39% female • 8.5% users: somewhat slower device Replied users (IID) Replied users (NonIID) JS JM JS JM JS JM loined users (IID) loined users (NonID) • 18-29y: 34% • 0.8% users: very slow device Mean(SD) Mean(SD) Mean(SD) Mean(SD) Mean(SD) 0.1 Available users (IID) Available users (NonIID) Optimal (ID) Optimal (NonID) • 30-39y: 41% Impact on Phone Battery: 0.0 P3a 167.3(13.1) 85.3(1.5) 17.9(2.1) 29.7(0.6) 56.8(8.6) 37.8(0.5) 10 2 з 5 6 8 q • 40-49y: 17% 73.7% remarked no change P4 117.1(1.1) 62.1(0.8) 15.4(0.1) 27.8(0.4) 41.3(0.9) 29.7(0.5) Joint Models • 50+y: 8% 0.6 • 22.7% noticed some change P5 115.0(0.4) 62.8(0.9) 16.1(0.1) 28.8(0.4) 42.7(1.0) 32.4(0.7) 3780 survey responses for feedback 3.6% noticed drastic change 0.5 **ON-DEVICE FUNCTION TIME COSTS** ° 2000 0.4 ACKNOWLEDGEMENTS OPEN-SOURCE CODE Joint Mode**l**s Total time per FL round Joint Samples 4CCU 1.00 1.00 1.00 This project has received funding from the https://github.com/FLaaSResearch est 0.2 European Union's Horizon 2020 Research 0.75 0.75 0.75 Replied users (IID) Replied users (NonIID) and Innovation program under Grant Agreements No 830927 (Concordia), No loined users (IID) loined users (NonID) <u>۵.50</u> 0.50 0.50 \*Work performed at Telefonica Research Join Round
Download Parameter Join Round 0.1 Available users (IID Available users (NonIID 871370 (Pimcity) and No 871793 Download Paramete 0.25 0.25 0.25 Optimal (IID) Optimal (NonIID) (Accordion). The poster reflect only the Load Samples
Conduct Training Load Samples Conduct Training ΡΙΜ — Joint Sample — Joint Models 0.0 **CONCQRDIA** view of the author(s) and the Commission 0.00 0.00 0.00 City 2 3 5 8 ġ 10 1 6 200 300 is not responsible for any use that may be 4 6 8 10 6 à 10 100 ACCORDION FL Rounds made of the information it contains Time (minutes) Time (minutes) Time (minutes)