Selected publications

- [1] Taveesh Sharma, Paul Schmitt, Francesco Bronzino, Nick Feamster, and Nicole Marwell. "Beyond Data Points: Regionalizing Crowdsourced Latency Measurements". In: *Proceedings of the ACM on Measurement and Analysis of Computing Systems* (2025).
- [2] Gerry Wan, Shinan Liu, Francesco Bronzino, Nick Feamster, and Zakir Durumeric. "CATO: End-to-end Optimization of ML Traffic Analysis Pipelines". In: *USENIX Symposium on Networked Systems Design and Implementation* (2025).
- [3] Youssouph Faye, Francescomaria Faticanti, Shubham Jain, and Francesco Bronzino. "VideoJam: Self-Balancing Architecture for Live Video Analytics". In: *IEEE/ACM Symposium on Edge Computing* (2024).
- [4] Xi Jiang, Shinan Liu, Aaron Gember-Jacobson, Arjun Nitin Bhagoji, Paul Schmitt, Francesco Bronzino, and Nick Feamster. "NetDiffusion: Network Data Augmentation Through Protocol-Constrained Traffic Generation". In: Proceedings of the ACM on Measurement and Analysis of Computing Systems (2024).
- [5] Manavjeet Singh, Sri Pramodh Rachuri, Bryan Bo Cao, Abhinav Sharma, Venkata Bhumireddy, Francesco Bronzino, Samir R. Das, Anshul Gandhi, and Shubham Jain. "OVIDA: Orchestrator for Video Analytics on Disaggregated Architecture". In: *IEEE/ACM Symposium on Edge Computing* (2024).
- [6] Shinan Liu, Francesco Bronzino, Paul Schmitt, Arjun Nitin Bhagoji, Nick Feamster, Hector Garcia Crespo, Timothy Coyle, and Brian Ward. "LEAF: Navigating Concept Drift in Cellular Networks". In: Proceedings of the ACM on Networking (2023).
- [7] Francesco Bronzino, Paul Schmitt, Sara Ayoubi, Hyojoon Kim, Renata Teixeira, and Nick Feamster. "Traffic Refinery: Cost-Aware Data Representation for Machine Learning on Network Traffic". In: Proceedings of the ACM on Measurement and Analysis of Computing Systems (2021).
- [8] Francesco Bronzino, Sumit Maheshwari, Ivan Seskar, and Dipankar Raychaudhuri. "NOVN: A namedobject based virtual network architecture to support advanced mobile edge computing services". In: Elsevier Pervasive and Mobile Computing (2020).
- [9] Francesco Bronzino, Paul Schmitt, Sara Ayoubi, Guilherme Martins, Renata Teixeira, and Nick Feamster. "Inferring Streaming Video Quality from Encrypted Traffic: Practical Models and Deployment Experience". In: Proceedings of the ACM on Measurement and Analysis of Computing Systems (2019).
- [10] Sumit Maheshwari, Dipankar Raychaudhuri, Ivan Seskar, and Francesco Bronzino. "Scalability and Performance Evaluation of Edge Cloud Systems for Latency Constrained Applications". In: IEEE/ACM Symposium on Edge Computing. 2018.

Preprints

- [11] Andrew Chu, Xi Jiang, Shinan Liu, Arjun Nitin Bhagoji, Francesco Bronzino, Paul Schmitt, and Nick Feamster. "NetSSM: Multi-Flow and State-Aware Network Trace Generation using State-Space Models". In: arXiv preprint arXiv:2503.22663 (2025).
- [12] Johann Hugon, Paul Schmitt, Anthony Busson, and Francesco Bronzino. "Cruise Control: Dynamic Model Selection for ML-Based Network Traffic Analysis". In: arXiv preprint arXiv:2412.15146 (2024).
- [13] Saloua Naama, Kavé Salamatian, and Francesco Bronzino. "Ironing the Graphs: Toward a Correct Geometric Analysis of Large-Scale Graphs". In: arXiv preprint arXiv:2407.21609 (2024).
- [14] Sean Flynn, Francesco Bronzino, and Paul Schmitt. "Internet Localization of Multi-Party Relay Users: Inherent Friction Between Internet Services and User Privacy". In: arXiv preprint arXiv:2307.04009 (2023).
- [15] Xi Jiang, Shinan Liu, Saloua Naama, Francesco Bronzino, Paul Schmitt, and Nick Feamster. "AC-DC: Adaptive Ensemble Classification for Network Traffic Identification". In: arXiv preprint arXiv:2302.11718 (2023).

Journals

- [16] Razanne Abu-Aisheh, Francesco Bronzino, Lou Salaün, and Thomas Watteyne. "CARA: Connectivity-Aware Relay Algorithm for Multi-Robot Expeditions". In: *MDPI Sensors* (2022).
- [8] Francesco Bronzino, Sumit Maheshwari, Ivan Seskar, and Dipankar Raychaudhuri. "NOVN: A namedobject based virtual network architecture to support advanced mobile edge computing services". In: Elsevier Pervasive and Mobile Computing (2020).

Conferences

- [1] Taveesh Sharma, Paul Schmitt, Francesco Bronzino, Nick Feamster, and Nicole Marwell. "Beyond Data Points: Regionalizing Crowdsourced Latency Measurements". In: *Proceedings of the ACM on Measurement and Analysis of Computing Systems* (2025).
- [2] Gerry Wan, Shinan Liu, Francesco Bronzino, Nick Feamster, and Zakir Durumeric. "CATO: End-to-end Optimization of ML Traffic Analysis Pipelines". In: *USENIX Symposium on Networked Systems Design and Implementation* (2025).
- [3] Youssouph Faye, Francescomaria Faticanti, Shubham Jain, and Francesco Bronzino. "VideoJam: Self-Balancing Architecture for Live Video Analytics". In: *IEEE/ACM Symposium on Edge Computing* (2024).
- [17] Andrea Fox, Francesco De Pellegrini, Francescomaria Faticanti, Eitan Altman, and Francesco Bronzino. "Optimal Flow Admission Control in Edge Computing via Safe Reinforcement Learning". In: International Symposium on Modeling and Optimization in Mobile, Ad hoc, and Wireless Networks. 2024.
- [4] Xi Jiang, Shinan Liu, Aaron Gember-Jacobson, Arjun Nitin Bhagoji, Paul Schmitt, Francesco Bronzino, and Nick Feamster. "NetDiffusion: Network Data Augmentation Through Protocol-Constrained Traffic Generation". In: Proceedings of the ACM on Measurement and Analysis of Computing Systems (2024).
- [5] Manavjeet Singh, Sri Pramodh Rachuri, Bryan Bo Cao, Abhinav Sharma, Venkata Bhumireddy, Francesco Bronzino, Samir R. Das, Anshul Gandhi, and Shubham Jain. "OVIDA: Orchestrator for Video Analytics on Disaggregated Architecture". In: *IEEE/ACM Symposium on Edge Computing* (2024).
- [18] Mathieu Guglielmino, Francesco Bronzino, and Sébastien Monnet. "Outil interactif pour l'alignement de la vue client-opérateur sur les architectures de réseau". In: Rencontres Francophones sur la Conception de protocoles, l'évaluation de performances et l'expérimentation de Réseaux de communication. 2023.
- [6] Shinan Liu, Francesco Bronzino, Paul Schmitt, Arjun Nitin Bhagoji, Nick Feamster, Hector Garcia Crespo, Timothy Coyle, and Brian Ward. "LEAF: Navigating Concept Drift in Cellular Networks". In: Proceedings of the ACM on Networking (2023).
- [19] Martino Trevisan, Idilio Drago, Paul Schmitt, and Francesco Bronzino. "Measuring the Performance of iCloud Private Relay". In: *Passive and Active Measurement Conference*. 2023.
- [20] Ayoub Ben Ameur, Andrea Araldo, and Francesco Bronzino. "On the deployability of augmented reality using embedded edge devices". In: *IEEE Annual Consumer Communications & Networking Conference*. 2021.
- [21] Francesco Bronzino, Nick Feamster, Shinan Liu, James Saxon, and Paul Schmitt. "Mapping the Digital Divide: Before, During, and After COVID-19". In: Research Conference on Communication, Information and Internet Policy (2021).
- [22] Francesco Bronzino, Sumit Maheshwari, Ivan Seskar, and Dipankar Raychaudhuri. "Application-Aware End-to-End Virtualization Using a Named-Object Based Network Architecture". In: *International Tele-traffic Congress*. 2021.
- [7] Francesco Bronzino, Paul Schmitt, Sara Ayoubi, Hyojoon Kim, Renata Teixeira, and Nick Feamster. "Traffic Refinery: Cost-Aware Data Representation for Machine Learning on Network Traffic". In: Proceedings of the ACM on Measurement and Analysis of Computing Systems (2021).

- [23] Shinan Liu, Paul Schmitt, Francesco Bronzino, and Nick Feamster. "Characterizing Service Provider Response to the COVID-19 Pandemic in the United States". In: *Passive and Active Measurement Conference*. 2021.
- [24] Francesco Bronzino, Sumit Maheshwari, Ivan Seskar, and Dipankar Raychaudhuri. "NOVN: named-object based virtual network architecture". In: *International Conference on Distributed Computing and Networking*. 2019.
- [9] Francesco Bronzino, Paul Schmitt, Sara Ayoubi, Guilherme Martins, Renata Teixeira, and Nick Feamster. "Inferring Streaming Video Quality from Encrypted Traffic: Practical Models and Deployment Experience". In: *Proceedings of the ACM on Measurement and Analysis of Computing Systems* (2019).
- [25] Ivan Morandi, Francesco Bronzino, Renata Teixeira, and Srikanth Sundaresan. "Service Traceroute: Tracing Paths of Application Flows". In: Conference on Passive and Active Network Measurement. 2019.
- [10] Sumit Maheshwari, Dipankar Raychaudhuri, Ivan Seskar, and Francesco Bronzino. "Scalability and Performance Evaluation of Edge Cloud Systems for Latency Constrained Applications". In: *IEEE/ACM Symposium on Edge Computing*. 2018.
- [26] Paul Schmitt, Francesco Bronzino, Renata Teixeira, Tithi Chattopadhyay, and Nick Feamster. "Enhancing Transparency: Internet Video Quality Inference from Network Traffic". In: Research Conference on Communication, Information and Internet Policy. 2018.
- [27] O Bulakci, DM Gutierrez-Estevez, M Ericson, A Prasad, E Pateromichelakis, G Calochira, J Belschner, P Arnold, F Sanchez Moya, AM Ibrahim, et al. "An agile resource management framework for 5G". In: *IEEE Conference on Standards for Communications and Networking*. 2017.
- [28] Shreyasee Mukherjee, Parishad Karimi, Dipankar Raychaudhuri, and Francesco Bronzino. "Enabling Advanced Network Services in the Future Internet Using Named Object Identifiers and Global Name Resolution". In: *International Conference on Communication Theory, Reliability, and Quality of Service*. 2017.
- [29] Francesco Bronzino, Dragoslav Stojadinovic, Cedric Westphal, and Dipankar Raychaudhuri. "Exploiting network awareness to enhance DASH over wireless". In: *IEEE Consumer Communications & Networking Conference*. 2016.
- [30] Shreyasee Mukherjee, Francesco Bronzino, Suja Srinivasan, Jiachen Chen, and Dipankar Raychaudhuri. "Achieving Scalable Push Multicast Services Using Global Name Resolution". In: *IEEE GLOBECOM*. 2016.
- [31] Francesco Bronzino, Dipankar Raychaudhuri, and Ivan Seskar. "Experiences with testbed evaluation of the mobilityfirst future internet architecture". In: *IEEE European Conference on Networks and Communications*. 2015.
- [32] Kai Su, Francesco Bronzino, KK Ramakrishnan, and Dipankar Raychaudhuri. "MFTP: A Clean-Slate Transport Protocol for the Information Centric MobilityFirst Network". In: International Conference on Information-Centric Networking. 2015.
- [33] Yu-Ting Yu, Francesco Bronzino, Ruolin Fan, Cedric Westphal, and Mario Gerla. "Congestion-aware edge caching for adaptive video streaming in information-centric networks". In: *IEEE Consumer Communications and Networking Conference*. 2015.
- [34] F. Bronzino, R. Gaeta, M. Grangetto, and G. Pau. "An adaptive hybrid CDN/P2P solution for Content Delivery Networks". In: *IEEE Visual Communications and Image Processing*. 2012.

Workshops

- [35] Andrew Chu, Xi Jiang, Shinan Liu, Arjun Bhagoji, Francesco Bronzino, Paul Schmitt, and Nick Feamster. "Feasibility of State Space Models for Network Traffic Generation". In: *Proceedings of the 2024 SIGCOMM Workshop on Networks for AI Computing* (2024).
- [36] Johann Hugon, Gaetan Nodet, Anthony Busson, and Francesco Bronzino. "Towards Adaptive ML Traffic Processing Systems". In: *Proceedings of the ACM CoNEXT Student Workshop 2023* (2023).

- [37] Xi Jiang, Shinan Liu, Aaron Gember-Jacobson, Paul Schmitt, Francesco Bronzino, and Nick Feamster. "Generative, High-Fidelity Network Traces". In: *Proceedings of the 22nd ACM Workshop on Hot Topics in Networks* (2023), pp. 1–7.
- [38] Xi Jiang, Shinan Liu, Saloua Naama, Francesco Bronzino, Paul Schmitt, and Nick Feamster. "Towards Designing Robust and Efficient Classifiers for Encrypted Traffic in the Modern Internet". In: *IAB workshop on Management Techniques in Encrypted Networks* (2022).
- [39] Shinan Liu, Francesco Bronzino, Paul Schmitt, Arjun Nitin Bhagoji, Nick Feamster, Hector Garcia Crespo, Timothy Coyle, and Brian Ward. "Understanding Model Drift in a Large Cellular Network". In: Practical Adoption Challenges of ML for Systems in Industry Workshop (2022).
- [40] Razanne Abu-Aisheh, Francesco Bronzino, Myriana Rifai, Lou Salaun, and Thomas Watteyne. "Coordinating a Swarm of Micro-Robots Under Lossy Communication". In: 2nd ACM International Workshop on Nanoscale Computing, Communication, and Applications. 2021.
- [41] Razanne Abu-Aisheh, Myriana Rifai, Francesco Bronzino, and Thomas Watteyne. "(POSTER) Impact of Connectivity Degradation on Networked Robotic Swarm Cooperation". In: 17th International Conference on Distributed Computing in Sensor Systems. 2021.
- [42] Francesco Bronzino, Elizabeth Cully, Nick Feamster, Shinan Liu, Jason Livingood, and Paul Schmitt. "Interconnection Changes in the United States". In: *IAB COVID-19 Workshop* (2021).
- [43] Francescomaria Faticanti, Francesco Bronzino, and Francesco De Pellegrini. "The case for admission control of mobile cameras into the live video analytics pipeline". In: 3rd ACM Workshop on Hot Topics in Video Analytics and Intelligent Edges. 2021.
- [44] Sri Pramodh Rachuri, Francesco Bronzino, and Shubham Jain. "Decentralized modular architecture for live video analytics at the edge". In: 3rd ACM Workshop on Hot Topics in Video Analytics and Intelligent Edges. 2021.
- [45] Razanne Abu-Aisheh, Francesco Bronzino, Myriana Rifai, Brian Kilberg, Kris Pister, and Thomas Watteyne. "Atlas: Exploration and Mapping with a Sparse Swarm of Networked IoT Robots". In: 16th International Conference on Distributed Computing in Sensor Systems. 2020.
- [46] Thierry Parmentelat, Thierry Turletti, Walid Dabbous, Mohamed Naoufal Mahfoudi, and Francesco Bronzino. "nepi-ng: an efficient experiment control tool in R2lab". In: 12th ACM International Workshop on Wireless Network Testbeds, Experimental evaluation & Characterization. 2018.
- [47] Francesco Bronzino, Shreyasee Mukherjee, and Dipankar Raychaudhuri. "The Named-Object Abstraction for Realizing Advanced Mobility Services in the Future Internet". In: Workshop on Mobility in the Evolving Internet Architecture. 2017.
- [48] P. Karimi, M. Sherman, F. Bronzino, I. Seskar, D. Raychaudhuri, and A. Gosain. "Evaluating 5G Multihoming Services in the MobilityFirst Future Internet Architecture". In: IEEE 85th Vehicular Technology Conference. 2017.
- [49] Francesco Bronzino and Dipankar Raychaudhuri. "Abstractions and Solutions to Support Smart-objects in the Future Internet". In: 2nd Workshop on Experiences in the Design and Implementation of Smart Objects. 2016.
- [50] Kiyohide Nakauchi, Francesco Bronzino, Yozo Shoji, Ivan Seskar, and Dipankar Raychaudhuri. "vMCN: virtual mobile cloud network for realizing scalable, real-time cyber physical systems". In: 4th Workshop on Distributed Cloud Computing. 2016.
- [51] Francesco Bronzino, Chao Han, Yang Chen, Kiran Nagaraja, Xiaowei Yang, Ivan Seskar, and Dipankar Raychaudhuri. "In-network compute extensions for rate-adaptive content delivery in mobile networks". In: *IEEE Workshop on Computer and Networking Experimental Research using Testbeds*. 2014.
- [52] Francesco Bronzino, Kiran Nagaraja, Ivan Seskar, and Dipankar Raychaudhuri. "Network service abstractions for a mobility-centric future internet architecture". In: Proceedings of the eighth ACM international workshop on Mobility in the evolving internet architecture. 2013.

Posters

- [53] Mathieu Guglielmino, Francesco Bronzino, Arnaud Sallaberry, and Sébastien Monnet. "(POSTER) MILADY (Matrix+ Linear Diagram): Visual Exploration and Edition of Multivariate Graphs for Computer Networks Management". In: The Eurographics Association (2023).
- [54] Razanne Abu-Aisheh, Myriana Rifai, Francesco Bronzino, and Thomas Watteyne. "(POSTER) Impact of Connectivity Degradation on Networked Robotic Swarm Cooperation". In: 2021 17th International Conference on Distributed Computing in Sensor Systems (DCOSS). IEEE. 2021, pp. 57–59.
- [55] Paul Schmitt et al. Correlating Network Congestion with Video QoE Degradation a Last-Mile Perspective. Talk at AIMS 2018, Workshop on Active Internet Measurements. 2018.
- [56] Francesco Bronzino et al. *Understanding and Improving video QoE a Last-Mile Perspective*. Poster at ACM Internet Measurement Conference (IMC) 2017. 2017.
- [57] Francesco Bronzino, Dipankar Raychaudhuri, and Ivan Seskar. "Demonstrating context-aware services in the mobility first future internet architecture". In: 28th International Teletraffic Congress. 2016.
- [58] Francesco Bronzino et al. Cloud Services Enhancements Through Application Specific Routing in MobilityFirst FIA. Poster and Demonstration at the 22nd GENI Engineering Conference (GEC-22). 2015.
- [59] Francesco Bronzino et al. Public Safety Focus: Connected Vehicles Assisting First Responders. Plenary talk and Demonstration at the 22nd GENI Engineering Conference (GEC-22). 2015.
- [60] Francesco Bronzino et al. Supporting Rich Network Services in Name Based Architectures. Talk at the NSF Future Internet Architecture Workshop. 2015.
- [61] Francesco Bronzino et al. In-Network Compute Layer in MobilityFirst Future Internet Architecture FIA. Poster and Demonstration at the 20th GENI Engineering Conference (GEC-20). 2014.
- [62] Francesco Bronzino et al. Introduction to the MobilityFirst FIA Protocol Suite. Tutorial at the 21st GENI Engineering Conference (GEC-21). 2014.
- [63] Francesco Bronzino et al. Context Services in MobilityFirst FIA. Plenary talk and Demonstration at the 18th GENI Engineering Conference (GEC-18). 2013.
- [64] Francesco Bronzino et al. MobilityFirst Network API use in Mobile Applications. Poster and Demonstration at the 16th GENI Engineering Conference (GEC-16). 2013.
- [65] Francesco Bronzino et al. Multi-Homing Support in MobilityFirst FIA. Poster and Demonstration at the 17th GENI Engineering Conference (GEC-17). 2013.

Tech reports

- [66] Razanne Abu-Aisheh, Francesco Bronzino, Myriana Rifai, Brian Kilberg, Kris Pister, and Thomas Watteyne. "Exploration and Mapping using a Sparse Robot Swarm: Simulation Results". PhD thesis. Inria, 2020.
- [67] Francesco Bronzino, Paul Schmitt, Sara Ayoubi, Nick Feamster, Renata Teixeira, Sarah Wasserman, and Srikanth Sundaresan. "Lightweight, General Inference of Streaming Video Quality from Encrypted Traffic". In: arXiv preprint arXiv:1901.05800 (2019).

Software and datasets

- [68] DecomposedRCPO. https://github.com/Andrea-Fox/DecomposedRCPO. 2024.
- [69] NetDiffusion: High-Fidelity Synthetic Network Traffic Generation. https://github.com/noise-lab/NetDiffusion_Generator. 2024.
- [70] VideoJam: Self-Balancing Architecture for Live Video Analytics. https://github.com/ENSL-NS/VideoJam. 2024.
- [71] LEAF cellular network KPI daily measurements dataset. https://forms.gle/g5pbB5qRHeBsEmZJ6. 2023.

- [72] Atlas: Exploration and Mapping with a Sparse Swarm of Networked IoT Robots. https://github.com/openwsn-berkeley/Atlas. 2022.
- [73] Traffic Refinery. https://traffic-refinery.github.io. 2021.
- [74] Labeled video sessions dataset. https://nm-public-data.s3.us-east-2.amazonaws.com/dataset/all_traffic_time_10.pkl. 2019.
- [75] Network Microscope. https://netmicroscope.com. 2019.
- [76] Service Traceroute. https://github.com/inria-muse/service-traceroute. 2019.
- [77] Video Collection Tools. https://github.com/inria-muse/video_collection. 2019.
- [78] HostView. https://github.com/inria-muse/. 2018.
- [79] MobilityFirst FIA Protocol Suite. https://mobilityfirst.orbit-lab.org/wiki/. 2017.
- [80] CoastKad. https://bitbucket.org/wontoniii/coastkad. 2012.

On the news

- [81] Enhancing Internet Resilience with Spatial Analysis. https://pulse.internetsociety.org/blog/enhancing-internet-resilience-with-spatial-analysis. 2024.
- [82] NetMicroscope Uses AI to Improve Network Monitoring for a Better Internet Experience. https://polsky.uchicago.edu/2024/02/01/netmicroscope-uses-ai-to-improve-network-monitoring-for-a-better-internet-experience/. 2024.
- [83] Two UChicago Startups Receive Investment from the George Shultz Innovation Fund. https://polsky.uchicago.edu/2024/01/23/two-uchicago-startups-receive-investment-from-the-george-shultz-innovation-fund/. 2024.
- [84] The Truth About Faster Internet: It's Not Worth It. https://www.wsj.com/graphics/faster-internet-not-worth-it/. 2019.
- [85] SES and Rutgers University test satellite content delivery network for sTreaming, OTT, and 5G. https://goo.gl/CjdmRy. 2016.
- [86] WINLAB develops infrastructure for potential new internet. https://www.dailytargum.com/article/2016/11/winlab-develops-infrastructure-for-potential-new-internet. 2016.
- [87] Deploying Future Internet Applications in Mobility First Project's GENI-Based Environment. https://bit.ly/31wCG2o. 2015.

Funding

- [88] AAP FIL INTERFERE: Stressing Systems Security Through on the Fly Network Traffic Generation (10k EUR). https://fil.cnrs.fr.
- [89] AAP USMB: Decentralized Live Video Analytics at the Network Edge (3k EUR).
- [90] AAP USMB: Federated Learning for Privacy Preserving Distributed ML (3k EUR).
- [91] ANR GTTP: Global Tracking Transfer Protocol (501k EUR). http://gttp.notion.site.
- [92] ANR NEMIoT: Network Methods for IoT (372k EUR). https://nemiot.univ-lyon1.fr.
- [93] ANR PARFAIT: Planning and Learning for AI-Edge Computing (560k EUR). https://parfait.univ-avignon.fr.
- [94] ANR-NSF MINT: Modeling Modern Network Traffic: From Data Representation to Automated Machine Learning (603k EUR). https://mint.univ-smb.fr.
- [95] FACCTS: Cost-Aware Feature Engineering and Model Selection forNetwork Traffic (22.5k USD). https://fcc.uchicago.edu/faccts/.
- [96] FACCTS: Detecting, Explaining, Mitigating Model Drift in Operational Networks (15k USD). https://fcc.uchicago.edu/faccts/.

- [97] FACCTS: Modeling Modern Network Traffic: From Data Representation to Automated Machine Learning (15k USD). https://fcc.uchicago.edu/faccts/.
- [98] In-Network Machine Learning (14k EUR).
- [99] Industrial contract with CELESTE (Half Ph.D. thesis funding) (84k EUR).