UNIVERSITÀ DEGLI STUDI DELL'AQUILA

Amministrazione centrale

AREA RICERCA E TRASFERIMENTO TECNOLOGICO

Settore Fundraising e gestione progetti di Ateneo

Progetti di Ateneo per la Ricerca di Base e Avvio alla Ricerca

Anno 2026

Bilò Davide

January 20, 2026

Università degli Studi dell'Aquila

Area Ricerca e Trasferimento Tecnologico

Settore Fundraising e gestione progetti di Ateneo

67100 L'Aquila (AQ), Italy

Con la presente si trasmette il modello (Allegato 1) per la presentazione della proposta progettuale, nell'ambito della selezione progetti di ateneo per la ricerca di base e l'avvio alla ricerca 2026.

Cordialmente,

Davide Bilò

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Responsabile del Settore: Dott.ssa Luisa De Matteis
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a) Titolo del progetto: SOS-TG: Spanners and Oracles for Static and Temporal Graphs

b) Proponente (PI): Davide Bilò (SSD: INFO-01/A, Area CUN: 01)

c) Posizione accademica del proponente: Associate Professor

d) Curriculum vitae del proponente (max 5000 caratteri – circa 2 pagine) con elenco delle pubblicazioni più significative (max 10) nel periodo 2021-2025, relative al tema del progetto.

PERSONAL DATA

Davide Bilò, born in Giulianova (TE), 11th of May 1978

Citizenship: Italian

ORCID: 0000-0003-3169-4300

EDUCATION AND TRAINING

- PhD in Computer Science at the University of L'Aquila in 2007
- Laurea cum laude in Computer Science at the University of L'Aquila in 2003

WORK EXPERIENCE

I became an Associate Professor at the University of Sassari in November 2019 and moved to the University of L'Aquila in late 2021. Prior to this, I was an Assistant Professor at Sassari (2010–2019), held a 2-year research grant at L'Aquila (2009–2010), and worked as a Postdoc at ETH Zurich (2007–2009).

È in possesso dell'Abilitazione Scientifica Nazionale per il ruolo di Professore di I Fascia nel settore scientifico disciplinare IINF/05.

SCIENTIFIC RESPONSIBILITIES

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- local organizer of ALGO 2026 in L'Aquila (the most prestigious European annual meeting on algorithms combining 7 conferences and workshops)
- local organizer and co-chair of the international conference RNDM 2017 sponsored by the IEEE (RNDM 2017)
- Associate editor for Theoretical Computer Science (from 2024 – present)
- Associate editor of Journal of Combinatorial Optimization (from 2024 – present)
- Associate editor of Journal of Computer and System Science (from 2024 – present)
- Editor of the Proceedings of RNDM 2017 (IEEE Italy Section, IFIP TC6 WG 6.10).
- I have served in the program committee of 28 international conferences (AAMAS 2026, AAAI 2026, IJCAI 2026, IWOCA 2026, AAAI 2025, AAMAS 2025, ALGOWIN 2025, CIAC 2025, COCOON 2025, IJCAI 2025, SOSA 2025, WADS 2025, AAMAS 2024, FUN 2024, IJCAI 2024, ISAAC 2024, ICTCS 2023, AAMAS 2023, IJCAI 2023, AAMAS 2022, AAMAS 2021, ICTCS 2021, ICTCS 2020, CSR 2020, ICTCS 2019, ARDA 2019, ICTCS 2018, ICTCS 2014).

RESEARCH PROJECTS AND FUNDINGS

- Principal Investigator of the "Spanners and Oracles in Static and Temporal Networks" project (University of L'Aquila, 2022).
- Mercator Fellow in the "Geometric Selfish Network Creation" project (German Research Foundation, 2020-2025).
- Principal Investigator of the "Algorithms for (fault-tolerant) pairwise spanners and distance oracles" project (Fondazione di Sardegna, 2018-2021).
- Participant in PRIN projects "ARS TechnoMedia" (2013-2016) and "Modelli per problemi di localizzazione/distribuzione/instradamento" (2011-2012).

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- Received funding from MIUR (2017) and the University of Sassari (2011, 2019, 2020).

PARTICIPATION TO RESEARCH GROUP ACTIVITIES

Davide Bilò collaborates with the following scientists

- Prof. Luciano Gualà from University of Rome "Tor Vergata" (Italy)
- Prof. Tobias Friedrich group at Hasso-Plattner Institute of Potsdam (Germany)
- Prof. Pascal Lenzner from University of Augsburg (Germany)
- Dr. Martin Schirneck from University of Karlsruhe (Germany)
- Prof. Sarel Cohen and Prof. Tami Tamir from Reichmann University (Israel)
- Prof. Shiri Chechik from Tel Aviv University (Israel)
- Prof. Keerti Choudhary from IIT Delhi (India).

CO-SUPERVISION OF PHD THESIS

I co-supervised 3 PhD thesis and I am currently supervising the PhD student Giordano Colli.

BEST PAPER AWARDS

- Blackout-Tolerant Temporal Spanners by D. Bilò et al. won the best student paper and the best paper at ALGOSENSOR 2022
- New Approximation Algorithms for the Heterogeneous Weighted Delivery Problem by D. Bilò et al. won best student paper at SIROCCO 2021
- Cutting Bamboo Down to Size by D. Bilò et al. won the best paper at FUN 2020

PARTICIPATION TO CONFERENCES AS AN INVITED SPEAKER

I was an invited speaker in 5 international conferences and workshops.

TEACHING EXPERIENCE

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Since 2023, I have taught "Web Algorithms," "Cloud Computing," and "Abilità Informatiche e Telematiche" at the University of L'Aquila. In 2021/2022, I co-taught "Laboratorio di Algoritmica Avanzata" with Prof. Stefano Leucci at L'Aquila. From 2011 to 2021, I taught basic Computer Science courses at the University of Sassari (160 hours/year). During my PhD and Post-Doc, I gave seminars and exercise classes at the University of L'Aquila and ETH Zurich.

PUBLICATIONS

78 conference publications and 35 journal publications

full list available at https://dblp.org/pid/31/5143.html

SELECTED PUBLICATIONS (related to the project proposal)

1. D. Bilò, L. Gualà, S. Leucci, G. Proietti, A. Straziota
   Almost Tight Oracles for Fastest-Path Queries on Temporal Trees
   ALGOWIN 2025
2. D. Bilò, G. D'Angelo, L. Gualà, S. Leucci, M. Rossi
   Blackout-tolerant temporal spanners.
   JCSS 2024
3. Efficient Fault-Tolerant Search by Fast Indexing of Subnetworks
   D. Bilò, K. Choudhary, S. Cohen, T. Friedrich, M. Schirneck
   AAAI 2025
4. Improved Distance (Sensitivity) Oracles with Subquadratic Space
   D. Bilò, S. Chechik, K. Choudhary, S. Cohen, T. Friedrich, S. Krogmann, M. Schirneck
   FOCS 2024

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5. Graph Spanners for Group Steiner Distances
   D. Bilò, L. Gualà, S. Leucci, A. Straziota
   ESA 2024
6. Approximate Distance Sensitivity Oracles in Subquadratic Space
   D. Bilò, S. Chechik, K. Choudhary, S. Cohen, T. Friedrich, S. Krogmann, M. Schirneck
   STOC 2023
7. Fault-Tolerant ST-Diameter Oracles
   D. Bilò, S. Chechik, K. Choudhary, S. Cohen, T. Friedrich, S. Krogmann, M. Schirneck
   ICALP 2023
8. Multiple-Edge-Fault-Tolerant Approximate Shortest-Path Trees
   D. Bilò, L. Gualà, S. Leucci, G. Proietti
   ALGORITHMICA 2022
9. Deterministic Sensitivity Oracles for Diameter, Eccentricities and All Pairs Distances
   D. Bilò, S. Chechik, K. Choudhary, S. Cohen, T. Friedrich, S. Krogmann, M. Schirneck
   ICALP 2022
10. Sparse Temporal Spanners with Low Stretch
    D. Bilò, G. D'Angelo, L. Gualà, S. Leucci, M. Rossi
    ESA 2022

Indicatori ASN 2024/26 alla scadenza del bando (solo per i progetti di ricerca) relativamente alla fascia superiore del Settore concorsuale e del Settore scientifico disciplinare di appartenenza.

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NOTA DELLA BANCA DATI IRIS:

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ASN 2023-2025

SECONDA FASCIA	Valore	INDICATORE	Soglia	Stato
	15	Numero articoli ultimi 5 anni	4	✓
	395	Numero citazioni ultimi 10 anni	157	✓
	12	H index ultimi 10 anni	7	✓
	La simulazione ASN per il ruolo di docente di Seconda Fascia ha esito positivo?			SI

PRIMA FASCIA	Valore	INDICATORE	Soglia	Stato
	22	Numero articoli ultimi 10 anni	9	✓
	635	Numero citazioni ultimi 15 anni	304	✓
	14	H index ultimi 15 anni	10	✓
	La simulazione ASN per il ruolo di docente di Prima Fascia ha esito positivo?			SI

COMMISSARIO	Valore	INDICATORE	Soglia	Stato
	22	Numero articoli ultimi 10 anni	11	✓
	635	Numero citazioni ultimi 15 anni	391	✓
	14	H index ultimi 15 anni	11	✓
	La simulazione ASN per il ruolo di Commissario ha esito positivo?			SI

e) Eventuali componenti del gruppo di ricerca (solo per i progetti di ricerca di base)

a. Davide Bilò (PI – SSD INFO-01/A – Area CUN: 01)

b. Gabriele Di Stefano (SSD IINF-05/A – Area CUN: 09)

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EXPERTISE

Davide Bilò has a strong background on the design and analysis of exact and approximation algorithms for several optimization problems on networks as well as on Algorithmic Game Theory. His current research interests include the design of spanners and oracles in networks that are prone to failures both in static and temporal graphs. He is also interested in the study and analysis of network formation composed by selfish agents.

Gabriele Di Stefano's research interests is in algorithm engineering, including distributed algorithms, recoverable robustness, network algorithms, combinatorial optimization, algorithmic graph theory. He is (co-)author of more than 130 publications in international journals and conferences in these areas.

f) Settore di ricerca ERC di riferimento per la proposta (indicare anche due sotto-settori): Settore PE6, sottosettori:

- PE6_6: Algoritmi, algoritmi distribuiti/paralleli, algoritmi su reti, teoria dei giochi algoritmica
- PE6_2: Sistemi di calcolo, sistemi distribuiti/paralleli, reti di sensori, sistemi embedded, sistemi cyber-fisici

g) Abstract (max 1000 caratteri)

This project proposal is about the design of algorithms for computing spanners and oracles in both static and temporal graphs, possibly in the presence of faults. A spanner is a sparse subgraph that approximates a property of interest, such as shortest-path distances, while an oracle is a compact data structure that supports fast queries for the same properties. In temporal

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graphs, edges are available only at specific time instants, making this model suitable to represent time-evolving networks where resources are intermittently available.

While spanners for static graphs have been extensively studied, including fault-tolerant variants, little is known about spanners and oracles in temporal graphs, even in the fault-free setting. Fault-tolerant temporal spanners, in particular, remain largely unexplored. Our goal is to attack open problems in the theory of spanners and oracles for static graphs and to significantly extend these concepts and techniques to the temporal domain.

h) Descrizione del progetto (max 8.000 caratteri, compresi eventuali riferimenti bibliografici. È consentito inserire figure nella proposta. Le figure non concorrono alla determinazione del calcolo del numero dei caratteri.)

a. Stato dell'arte

One of the central topics in theoretical computer science is the design of spanners and oracles. Spanners were introduced in [14,15] and have since attracted substantial attention due to their wide applicability in communication networks, distributed systems, robotics, and related areas [13].

A spanner is a sparse subgraph that preserves certain properties of interest (e.g., reachability or shortest-path distances), either exactly or approximately, even in the presence of failures. For example, to preserve distances from a single source in a failure-free setting, it suffices to select a shortest-path tree. However, the problem becomes significantly more challenging in fault-prone networks, which has motivated extensive research in the area (see [1] for a survey).

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The combinatorial structure of spanners becomes even richer when considering temporal graphs, where each edge is available only at specific time instants. Temporal graphs have received considerable attention in the broader algorithmic community [12], yet the design of sparse temporal spanners has been explored only recently [7], and primarily under the all-to-all reachability requirement and in the absence of failures.

A natural counterpart to spanners is the design of compact data structures, known as oracles, which answer queries about connectivity or shortest-path distance properties (possibly under failures) [5,8–10]. In a sense, spanners can be viewed as data structures that encode a subgraph preserving the properties of interest, but they may not support fast queries. Oracles, by contrast, are not restricted to store a subgraph; instead, they may use any encoding strategy as long as they can answer queries quickly.

b. Obiettivi

The main goal of this project is to design and analyze algorithms for constructing spanners and oracles in both temporal and fault-prone networks. In particular, the key technical challenges we address can be summarized as follows:

FAULT-TOLERANT SPANNERS AND ORACLES. We study open problems in the design of spanners and oracles for static networks subject to multiple failures. While the all-to-all case with exact or near-exact distances is well understood [8–10, 18-19], the problem remains unresolved when the size of the data structure is sublinear in the input size [2,4]. Moreover, the single-source counterpart is poorly understood when one seeks an almost-linear-size spanner that preserves distances within a constant additive or multiplicative approximation under a constant number of failures [5]. We also investigate the preservation of alternative metric properties, following recent work in [3].

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TEMPORAL SPANNERS AND ORACLES. Designing temporal spanners that preserve exact or approximate temporal distances in the single-pair, single-source, and all-to-all settings is a natural extension of the all-to-all reachability problem originally defined in [7] and represents the temporal analogue of static graph spanners (see [6] for discussion about concepts of temporal distances and known results). These problems are challenging because techniques from static graphs do not readily transfer to the temporal domain. For instance, preserving all-to-all reachability is trivial in static graphs, whereas it requires substantial technical effort in temporal graphs and has only recently been addressed [7, 16-17]. The design of temporal oracles is even more challenging, as no results are currently known.

FAULT-TOLERANT TEMPORAL SPANNERS. We also consider the design of sparse temporal spanners in the presence of temporal edge failures, i.e., failures that are time-dependent. This setting is inherently more complex than the individual temporal or fault-prone cases [6], as it requires managing the interaction between time evolution and failures. This direction is largely unexplored and represents a step towards more realistic network models in which resources may become temporarily unavailable due to transient failures. Related combinatorial problems that share similar features, though not directly focused on temporal sparsification, have been recently studied in [11].

c. Metodologia

This project lies within the algorithmic domain, a central area of theoretical computer science. Theoretical computer science bridges computer science and mathematics by focusing on the foundational and mathematical aspects of computation, including the theory of computation and algorithm design.

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Our methodological approach follows the standard paradigm in the field and is based on fully rigorous mathematical analysis. For each proposed algorithm, we will provide formal proofs of correctness and try to derive tight bounds on performance, characterizing the trade-offs between solution quality and computational resources. We will analyze time complexity, space requirements, and approximation guarantees (where exact solutions are infeasible). When applicable, we will also investigate lower bounds and hardness results to delineate the limits of efficient computation.

The results will be disseminated through publications in top peer-reviewed conferences and high-quality journals. Additionally, we will organize a dedicated workshop to present our findings to leading experts in the area. This workshop will also serve to strengthen existing collaborations and to foster new research partnerships.

d. Piano di lavoro

We will tackle the proposed research problems in a staged manner, prioritizing them according to their complexity and our expertise. Based on our experience, the static setting is more mature than its temporal counterpart. Indeed, the algorithmic theory of static networks benefits from a long-standing history and a rich toolkit of well-established graph-theoretic methods, whereas the foundational analysis of temporal networks is still emerging.

Accordingly, we will first focus on the design of fault-tolerant spanners for temporal graphs, before addressing the corresponding oracle constructions. This progression reflects a widely held view in the research community that oracle design is typically more challenging than spanner design, and that insights gained from spanners often guide the development of efficient oracles.

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To accelerate progress and ensure continuous intellectual exchange, we will undertake short-term research visits to leading universities and research centers, and we will actively participate in international conferences, workshops, and symposia aligned with the project. These activities will strengthen collaborations, foster knowledge transfer, and keep the project aligned with the latest advances in the field.

REFERENCES

[1] A.R. Ahmed, G. Bodwin, F.D. Sahneh, K. Hamm, M.J.L. Jebelli, S.G. Kobourov, R. Spence, Graph spanners: A tutorial review, Comput. Sci. Rev., 2020

[2] D. Bilò, S. Chechik, K. Choudhary, S. Cohen, T. Friedrich, S. Krogmann, M. Schirneck , Improved Distance (Sensitivity) Oracles with Subquadratic Space, FOCS 2024

[3] D. Bilò, L. Gualà, S. Leucci, A. Straziota, Graph Spanners for Group Steiner Distances, ESA 2024

[4] D. Bilò, S. Chechik, K. Choudhary, S. Cohen, T. Friedrich, S. Krogmann, M. Schirneck, Approximate Distance Sensitivity Oracles in Subquadratic Space, STOC 2023

[5] D. Bilò, L. Gualà, S. Leucci, G. Proietti, Multiple-Edge-Fault-Tolerant Approximate Shortest-Path Trees, ALGORITHMICA 2022

[6] D. Bilò, G. D'Angelo, L. Gualà, S. Leucci, M. Rossi, Sparse Temporal Spanners with Low Stretch, ESA 2022

[7] A. Casteigts, J.G. Peters, J. Schoeters, Temporal cliques admit sparse spanners, JCSS, 2021

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[8] S. Chechik, S. Cohen, A. Fiat, H. Kaplan, (1+ε)-Approximate Sensitive Distance Oracles, SODA 2017

[9] R. Duan, Y. Gu, H. Ren, Approximate Distance Oracles Subject to Multiple Vertex Failures, SODA 2021

[10] D. Dey, M. Gupta, Nearly Optimal Fault Tolerant Distance Oracle. STOC 2024

[11] E. Füchsle, H. Molter, R. Niedermeier, M. Renken, Delay-Robust Routes in Temporal Graphs, arXiv:2201.05390

[12] O. Michail, An Introduction to Temporal Graphs: An Algorithmic Perspective, Internet Math., 2016

[13] D. Peleg, Distributed computing: A locality-sensitive approach, SIAM, ISBN: 0-89871-464-8, 2000

[14] D. Peleg, A.A. Schaffer, Graph spanners, J. on Graph Theory, 1989.

[15] D. Peleg, E. Upfal, A trade-off between space and efficiency for routing tables, J. of the ACM, 1989.

[16] S. Angrick, B. Bals, T. Friedrich, H. Gawendowicz, N. Hastrich, N. Klodt, P. Lenzner, J. Schmidt, G. Skretas, A. Wells, How to Reduce Temporal Cliques to Find Sparse Spanners. ESA 2024

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[17] D. Carnevale, A. Casteigts, T. Corsini, Dismountability in Temporal Cliques Revisited. SAND 2025

[18] S. Cicerone, G. Di Stefano, D. Handke, Self-spanner graphs. DAM 2005

[19] S. Cicerone, G. Di Stefano, Networks with small stretch number. JDA 2004

i) Elementi di originalità e innovazione della proposta e impatto in termini di rilevanza dell'avanzamento nella ricerca di base per la comunità scientifica di riferimento (max 3000 caratteri)

We believe that, in the long term, efficient algorithms for constructing spanners and oracles will have a profound impact on the performance, reliability, and scalability of large communication networks. Beyond their foundational role in graph theory and robotics [13], fault-tolerant spanners and oracles are central to many core areas of computer science and engineering. They underpin space-efficient routing tables [13–15] and play a crucial role in synchronizers—algorithmic frameworks that enable synchronous protocols to be executed in asynchronous distributed systems [13–15]. Fault-tolerant spanners and oracles are also essential in parallel and distributed algorithms for computing approximate shortest paths, enabling faster and more scalable computation on massive graphs [13]. More broadly, spanners have wide applicability across labeling schemes [20], routing [19], solving linear systems [19], and spectral sparsification [21], impacting areas such as optimization, machine learning, and scientific computing.

This project aims to advance the state of the art by improving trade-offs in classical spanner design problems, particularly those involving distance preservation and approximation. We will also propose novel models that preserve alternative metric properties, expanding the reach

of spanners and oracles to new settings and applications. These contributions are expected to influence both theory and practice, leading to more resilient and efficient network infrastructures.

Although temporal networks are still in their early stages, they already support a compelling set of applications across diverse domains [12]. Many systems naturally fit the temporal graph model, including transportation networks, communication infrastructures, social networks, and physical systems (see [12] and the references therein). Temporal constraints are also fundamental in epidemic modeling [22], where contacts evolve over time and the goal is to understand how an infectious disease, or a computer virus, spreads through the network. Temporal graph models are also relevant to scheduling, supply chains, and time-dependent routing, where resources are available only at specific times and decisions must account for dynamic availability [12].

In contrast to static networks, where analytical tools are well developed, foundational tools for temporal spanners and oracles are still largely missing. This gap limits our ability to design efficient, reliable solutions for time-varying systems, despite their growing importance in modern infrastructures [12]. By developing novel methodologies and theoretical frameworks for temporal spanners and oracles, this project will bridge a critical knowledge gap and provide a foundation for future research. The expected outcomes will not only advance the theoretical frontier but also enable more efficient and robust design of real-world systems, with long-term benefits for communication networks, transportation, and beyond.

[18] B. Bollobás, D. Coppersmith, M. Elkin, "Sparse distance preserver and additive spanners", SIAM J. on Discrete Mathematics, 2005.

[19] M. Elkin, "Computing almost shortest paths", ACM Transactions on Algorithms, 2005.

[20] C. Gavoille, D. Peleg, "Compact and localized distributed data structures", Distributed Computing, 2003.

[21] M. Kapralov, R. Panigrahy, R., "Spectral sparsification via random spanners", ITCS 2012.

[22] Cai, Nie, Holme, Epidemic criticality in temporal networks, Physical Review Research 2024

j) Impatto del progetto in riferimento alle tematiche di genere (facoltativo, max 3000 caratteri)

Fault-tolerant spanners preserve connectivity by ensuring alternative routes remain available even when key links or nodes fail. In social networks representing mentorship, professional connections, or community support, the loss of a few central actors can sever access to essential opportunities. Fault-tolerant spanners mitigate this risk by maintaining reachability, particularly in temporal settings where relationships evolve and disruptions occur at specific moments.

Fault-tolerant distance oracles enable fast, robust analysis of how disruptions reshape access and influence. They can identify communities that become isolated or disadvantaged when certain connections fail, supporting early intervention and policy design. In the context of gender equality, these tools can reveal structural gaps in professional networks, digital platforms, and community support systems that disproportionately exclude women, enabling targeted measures to strengthen inclusion.

By advancing theoretical foundations and practical efficiency for temporal and fault-tolerant network models, this project supports the design of more resilient and inclusive digital and physical infrastructures.

Piano di spesa

Voce di spesa	*Importo (Euro)*
Borse di studio ricerca (art.2 del Regolamento per il conferimento di borse di ricerca attualmente in vigore)	0
Rinnovo Co-finanziamento assegni di ricerca	0
Materiali di consumo	500
Attrezzature, strumentazioni, software	5.000
Missioni	7.000
Acquisto prodotti ritenuti necessari per la realizzazione del progetto (es. materiale librario, licenze per l'accesso a banche dati, ecc.)	500
Pubblicazioni, organizzazione di convegni e workshop	2.000
TOTALE	**15.000**

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