**PERFORMANCE WORK STATEMENT**

5G/6G Core Networks and Algorithms Support Services

**BACKGROUND INFORMATION**

The Transformational Networks and Services Group (TNSG) in the Smart Connected Systems Division, Communications Technology Laboratory (CTL) at the National Institute of Standards and Technologies (NIST) develops foundational network science, network measurement science, standards, and best practices to support the transformation of industries critical to national priorities such as industrial automation and smart transportation. TNSG’s research efforts include fifth and sixth generation (5G/6G) core networks, edge and distributed AI (Artificial Intelligence) and their applications to networking, AI-based autonomous networking, optical and quantum networking, cloud computing, information-centric networks, and automated driving.

**PURPOSE**

The purpose of this requirement is to obtain contractor services to develop AI and ML (machine learning) techniques (including models and algorithms) for supporting 5G/6G networks, quantum networks, and applications over such emerging networks; create new AI-based architectural concepts for such networks; and develop test methods and tools for evaluating the new techniques.  
  
**SCOPE OF WORK**  
  
The Contractor shall design, evaluate, and demonstrate new models and algorithms for supporting edge and distributed AI, AI-based network architectures, assurance of end-to-end (E2E) network service qualities, management of E2E interservice interference, and advanced routing for 5G/6G networks and quantum networks. More specifically, the Contractor shall provide research support and design distributed optimization and learning algorithms for the following:

1. New edge and distributed machine learning for supporting 5G/6G networks and applications.
2. Optimal resource allocation for E2E quality-of-service (QoS) assurance over 5G/6G networks.
3. Efficient entanglement routing in quantum networks.

The Contractor shall work closely with a team of CTL scientists who are working on 6G core networks, where this project is located. The Contractor shall assist in the design and implementation of a 5G core network testbed, tests and data collection, and evaluation of the new AI/ML algorithms for supporting networking functions and selected applications (such as automated driving). The Contractor shall also support collaborations with internal and external collaborators.

**REQUIREMENTS**

The Contractor shall provide all support for project oversight, administration, and technical execution of this contract. The Contractor is responsible for maintaining accurate records of project activities. All deliverables shall be Section 508 Compliant, as applicable.   
  
The Contractor shall perform the following services

1. **5G/6G Core Networks and Algorithms Support Services**
   1. **Develop and Evaluate Edge and Distributed Learning Techniques:** The Contractor shall extend the Federated Learning algorithm developed by TNSG to increase performance, provide theoretical and experimental evaluations of the new algorithms, including defining the necessary evaluation metrics, and investigate how edge learning can be used to enable new applications, including spectrum sharing and remote driving.
   2. **Design E2E QoS Assurance Algorithms:** The Contractor shall extend the E2E QoS assurance methods developed by TNSG to increase performance, define metrics and develop algorithms for measuring E2E interservice interferences, develop algorithms for automatically analyzing the risks of network events, and provide theoretical analyses and numerical evaluations of the new algorithms.
   3. **Develop Entanglement Routing Algorithms for Quantum Networks:** The Contractor shall analyze limitations of current entanglement routing techniques, develop a new algorithm for entanglement routing between concurrent source-destination pairs via untrusted repeater nodes, and provide theoretical analyses and numerical evaluations of the algorithm.
2. **Progress Reporting**   
   1. Submit monthly progress reports which detail progress made during the prior month, progress expected for the next month, any significant problems, risks or issues encountered, recommended actions to resolve identified problems, and any variances or expected variances from scheduled due dates. Monthly progress reports shall be due on the 10th of each month, beginning during the first full month of performance (if the performance period starts on a date other than the first of the month), covering all activity during the preceding month.
   2. Participate in weekly status meetings with the NIST Contracting Officer’s Representative (COR) to discuss progress to date. These meetings shall take place via telephone or virtual video call and are expected to take no more than one hour each.

**DELIVERABLES**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Task**  **Number** | **Description** | **Format** | **Quantity** | **Date Required** |
| 1-a | Develop and evaluate edge and distributed learning techniques | MSWord or PowerPoint | 1 | 12 months from start of award POP |
| 1-b | Design E2E QoS assurance algorithms | MSWord or PowerPoint | 1 | 12 months from start of award POP |
| 1-c | Develop entanglement routing models for quantum networks | MSWord or PowerPoint | 1 | 12 months from start of award POP |
| 2 | Monthly Progress Report | MSWord via email | 1/month | Monthly |

**STANDARDS FOR ACCEPTANCE OF DELIVERABLES**

As tasks and deliverables are completed, the Contractor shall submit the deliverables for review to the NIST COR. The COR will provide comments on any given deliverable within 7 calendar days after receipt. The Contractor shall revise and resubmit the deliverable(s) within 7 calendars after receipt of COR feedback. All revisions shall be made at no additional cost to the Government. The COR will provide notification when deliverables are accepted.

**PERFORMANCE REQUIREMENTS SUMMARY**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Task Number** | **Desired Output** | **Required Service** | **Performance Standard** | **Monitoring Method** |
| 1-a | Develop and evaluate edge and distributed learning techniques | Develop and conduct mathematical and experimental evaluation of new edge and distributed learning algorithms for supporting 5G/6G networks and selected applications | Documentation and demonstration of the new algorithms and their applications. | NIST COR shall review the progress of the AV evaluation effort and determine its acceptability |
| 1-b | Design E2E QoS assurance algorithms | Develop and conduct mathematical and experimental evaluation of new techniques for supporting E2E service assurance for 5G/6G networks and selected applications. | Documentation and demonstration of the new algorithms and their applications. | NIST COR shall periodically review the progress of the study and determine acceptability |
| 1-c | Develop entanglement routing models for quantum networks | Develop and conduct mathematical evaluation of new techniques for supporting routing over quantum networks. | Documentation and theoretical evaluation of the new algorithms and their applications | NIST COR shall review the quality of the measurements and determine acceptability |
| 2 | Progress Reporting | Submit monthly progress reports and participate in weekly status meetings | Reporting is timely and in accordance with all requirements identified in this document | NIST COR Review |

**PERIOD OF PERFORMANCE**

The period of performance shall be for one year from August 29, 2024 through August 28, 2025.

**PLACE OF PERFORMANCE**

The primary place of performance shall be the NIST campus located at 100 Bureau Drive, Gaithersburg, MD 20899-1640.   
  
Work may be performed offsite during times when NIST is closed or access is restricted. Offsite work may also be permitted whenever it is determined to be advantageous to the Government for progress or performance of the work. All offsite work or telework requests must be approved prior by the COR.

All work shall be accomplished Monday through Friday except for Federal holidays or other official closures

**TRAVEL REQUIREMENTS**

NIST anticipates travel for up to two domestic trips may be to attend conferences to present the results of research and its impact. Each trip is expected to be less than a week in duration.

NIST will provide at least three weeks of advance notification for upcoming travel requirements. Notification will include dates and location of travel.

All travel shall be approved in advance. Approved travel shall be reimbursed in accordance with the Federal Travel Regulation up to the not-to-exceed amount of $3,500.00.

The Contractor shall be responsible for making all travel arrangements including but not limited to airline tickets, hotel, car rental reservations, etc. Travel estimates shall be provided to the NIST COR for written approval prior to incurring costs. When requesting reimbursement for travel costs, the Contractor shall submit an invoice with a detailed breakout of the reimbursable travel costs. The Contractor shall make every effort to keep travel costs to a minimum.

**KEY PERSONNEL REQUIREMENTS**

NIST estimates that one (1) Key Personnel is required to perform this requirement. The key personnel shall meet the following minimum qualifications:

* A Ph.D degree in an area closely related to the work, such as computer science, computer engineering, mathematics, or statistics.
* Six (6) years of experience in convex optimization, theoretical and practical design and evaluation of machine learning algorithms, algorithm design and analysis, and epidemic modeling.
* Six (6) years of experience in independent design, efficient implementation, and testing of all aspects of an optimization or machine learning algorithm in a testbed.
* Six (6) years of experience of using popular machine learning libraries such as TensorFlow and PyTorch.
* Three (3) years of experience working on 5G networks and mechanisms for supporting end-to-end quality of services.
* Six (6) years of experience working with software version control systems such as GitHub.

**GOVERNMENT FURNISHED PROPERTY**

Government-furnished equipment will be provided in an as-is condition and in a working condition. Upon award, the Government will provide the Contractor with equipment needed in the performance of this requirement including office space, a desk, chair, office telephone, and a computer. All equipment provided shall be returned to the Government at the end of the award in the condition it was received in.  
  
All property, data, and information provided by the Government in the performance of this task remains the property of the Government and shall be surrendered to the government upon completion or termination of this requirement. Likewise, all deliverables generated under this requirement are the property of the Government.

**RISK LEVEL ASSESSMENT**This requirement is identified as Information Technology (IT) Low Risk and Non-IT Low Risk. The contractor will have access to a NIST computer and email account.  **CONTRACT TYPE**

Firm-Fixed Price.