Simplified NIF for GN4 Input

Overview

Project Name:	High Accuracy Time Service (HATS)	Project Proposer:	Jerry Sobieski

Project Type: GN4 Phase1 or longer term	GN4 Phase 1.	**Estimated Project Costs (best effort!)**	
Duration proposed	1 year, with follow on Phase 2 of several years (Phase 2 not covered in this NIF)	Manpower in person-months also identifying specific expertise required	TBD. Construction of the repeater and HATS signal convergence function is unknown. This will likely require a Senior SME timing wizard, an additional software/microcode systems programmer, and a hardware engineer to construct the repeater platform. 3 FTEs for 1 year = ~ 500K EUR.
Deliverables proposed (If any can be defined at this stage)	Demonstrable time coordination among geographically distributed sites	Hardware and equipment:	A minimum of three HATS repeater devices must be constructed to prove viability. It is unknown what optical or computational equipment is required. So we presume approximately 100K EUR for these devices. Further, we presume two additional fiber segments must be engineered to support the timing signal. Those segments will require $50K EUR per segment for splitters and bidirectional amplifiers etc. This is total guess at cost for this

Milestones proposed (If any can be defined at this stage)	Other costs	equipment...if the NIF concept is appealing, we should ask an SME to provide more accurate project plan and costing.
		Travel and remote access support (for access to long haul huts and pops.) = 20K EUR for remote Eyes and hands. And 6 trips for the year = 15K Eur
		Total estimated cost = 615K EUR.

1 **Background** and Reasoning

Provide background information and the context of the project. Explain the reason for the project. What do you want to be different? What do you hope to improve? Why is the project needed? This should be the reason for the project, not the solution.

To date, communicating highly accurate coordinated time across geographically large distances has been provided by GPS clock. This has been sufficient to reach a clock resolution of about 40 ns (approximately $4*10^{-8}$ seconds) However, emerging science requires highly accurate time that is of much finer resolution. Many of these applications currently use local hydrogen maser clocks that provide 10^{-12} or finer resolution.

Recent advances in the transfer of Time and Frequency information using basic telecommunications fiber infrastructure suggests that clocks in the range of 10^{-15}s or smaller resolution can be expressed across terrestrial "well engineered" long-haul fibers. Clocks of this resolution can enable a whole new class of science programs. For instance, eVLBI programs could use the 10^{-15} resolution to timestamp its multiple quasar traces without having to build and/or maintain (and then coordinate) its own highly accurate clocks. More generally, time based distributed scientific instruments could be conceived and easily constructed that span continents(!).

Additionally, such a Highly Acurate Timing Service (HATS) could be used to provide high resolution timing for studying network performance. Indeed, this can enable end to end one way latency measurements without dependence on external clock services, and enable 100 Gbps jitter studies. It is interesting to note that even the GPS system is subject to governmental mischief that periodically adjusts clocks to intentionally reduce the accuracy or granularity of the signal. This is most commonly done for military or other national defense purposes. Regardless, it is outside of the control of GEANT or the academic community and so a better solution would be to use a timing source that is under the control of GEANT and maintained as part of the GEANT service portfolio.

This NIF proposes to extend the existing work of NEAT-FT and the ICOF Open Call to show that it is not only possible to transfer time and frequency over long distance on a telecom fiber infrastructure, but that this time can than be repeated across additional fiber links in a synchronous fashion and presented at each hop as a service. The vision is that such service could be designed that presents a clock with very (VERY!) fine

grained "ticks" at every GEANT PoP.   These clocks could likewise be extended into peering domains where raw fiber is used cross-border for the R&E network(s).

There is much work required to deliver a mature HATS capability. This 1 year NIF proposes only to show that, in principle, a mesh of [repeated] HATS services is possible.   So this NIF is dependent upon a) the photonic transfer of T&F across the fiber span between network nodes, and b) the successful coordination and/or repeating of T&F information across the network node.   This NIF will focus on the latter.

2   Objectives, Impact and Benefits

Provide one or more bullet points to briefly describe the primary objective(s) of the project in terms of the desired outcomes. This should be expressed in the form: 'To ensure…', 'To implement…', 'To service...', 'To improve...', 'To innovate...', 'To optimize...', 'To save...', etc. For each objective mention the benefits to identified stakeholders (e.g. end-users, NRENs, large international research projects, industrial research partners, high level education, etc.) should be mentioned. A description of the expected overall impact must also be provided.

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3   Scope

Describe the areas expected to be covered or impacted by the proposed activity, such as organisational areas, systems, processes, resources.. i.e. what is 'in scope'. This is not a list of what will be done but identifying the services, areas or what, will be affected.

Also please enumerate specific items which although they could perhaps be related are intentionally not addressed by your proposal ("Out of Scope").

1.   In Scope

Anything technology that is required or could be used to successfully express a 10^-15 or finer clock across the terrestrial fiber plant of GEANT is within scope.   Further, any technology that is necessary or helpful to moving a HATS clock signal across the GEANT PoP is within scope.   Specifically, one must consider not only how to repeat the signal, but for scalability we must understand how to reconcile or coordinate multiple HATS signals that may be convergent on a single node.   Thus each node implements a distributed algorithm that will ultimately allow the HATS signals to converge to a single common timing signal.   It is not clear how to accomplish this convergence algorithm.

2.   Out of Scope

This NIF does not propose to create an actual HATS service that is ready for formal deployment.   There are additional issues that must be pursued – for instance security, or intercontinental HATS convergence, etc. These aspects could be addressed in Phase 2 of GN4 if the general feasibility of the fiber distributed T&F service is proven out and we understand better the technical design that must be hardened for production.

General Information

Outline any potential issues, risks, dependencies, assumptions, constraints and limitations or any other points that may be useful to help assess the proposal.

This project is still basic research and so should be placed in a JRA task.   The objective should be – in the Big Picture – to provide a Highly Accurate Time Service, not necessarily to force the current fiber based T&F distribution technology to be the solution.   Thus it might be prudent to place highly accurate independent clock sources throughout the GEANT core and structure the coordinated time mesh in some other manner.   The end game is to deliver a Time Service – not to use a particular technology to do so.   While we believe the NEAT-FT/ICOF concepts are important and promising in terms of viability, we have yet to complete their proof of concept in GN3plus.

This project requires access to dark fiber in order to engineer the optical layer to propogate the analog optical timing signal properly.   Currently ICOF has access to one segment of fiber between Paris and London.   This proposal would require nominally two additional fiber segments that could be connected to the London and Paris end points.   Or alternatively other fiber infrastructure elsewhere.   We assume that the fiber is already in hand

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