A Completely, One-Hundred Percent Correct Construction of Superluminal Communication

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Abstract

We construct a mixed mathematical (when it suits us) and practical (when it suits us) method of "simultaneous" (a hand-wavy definition) information transfer using qubits and potentially impossible machines. We have accomplished that which Schrödinger and Einstein could only dream: if only they had undergraduate degrees in mathematics and rudimentary LateX skills.

1 Scaffolding

We first define a **basis** as a subset of vectors, $\{\hat{\mathbf{v_1}}, ...\hat{\mathbf{v_n}}\}$ in a vector space $\mathbb{V}$, and a corresponding inner product $\langle , \rangle$ such that $\langle \hat{\mathbf{v_i}}, \hat{\mathbf{v_j}} \rangle = 0$ when $i \neq j$ and $\langle \hat{\mathbf{v_i}}, \hat{\mathbf{v_i}} \rangle = 1$. Any $v \in \mathbb{V}$ can then be described as a linear combination of these basis vectors. By definition, each $\hat{\mathbf{v_i}}$ is unit, denoted by the hat symbol.

A **qubit** can be described by its **state vector**, which is a linear combination of basis vectors.

$$\vec{\mathbf{q}} = c_0 \hat{\mathbf{v_0}} + ... + c_n \hat{\mathbf{v_n}} \ni c_i \in \mathbb{R}$$

For the purposes of this paper, we will only consider qubits in two dimensions. This allows us to use basis vectors in $\mathbb{R}^2$ and avoid complex numbers.

Each c_i we will call a **probability amplitude**. These are related by their sum.

$$\sum_i {c_i}^2 = 1$$

We can combine two state vectors, $\vec{\mathbf{a}}$ and $\vec{\mathbf{b}}$ using the **tensor product**. This is defined by:

$$
\begin{aligned}
\vec{\mathbf{a}} \otimes \vec{\mathbf{b}} &= (c_0\hat{\mathbf{a_0}} + c_1\hat{\mathbf{a_1}}) \otimes (d_0\hat{\mathbf{b_0}} + d_1\hat{\mathbf{b_1}}) \\
&= c_0 d_0 \hat{\mathbf{a_0}}\hat{\mathbf{b_0}} + c_0 d_1 \hat{\mathbf{a_0}}\hat{\mathbf{b_1}} + c_1 d_0 \hat{\mathbf{a_1}}\hat{\mathbf{b_0}} + c_1 d_1 \hat{\mathbf{a_1}}\hat{\mathbf{b_1}} \\
&= r(\hat{\mathbf{a_0}}\hat{\mathbf{b_0}}) + s(\hat{\mathbf{a_0}}\hat{\mathbf{b_1}}) + t(\hat{\mathbf{a_1}}\hat{\mathbf{b_0}}) + u(\hat{\mathbf{a_1}}\hat{\mathbf{b_1}}) \ni r^2 + s^2 + t^2 + u^2 = 1 \quad (1)
\end{aligned}
$$

Finally, with the tensor product defined, we can specify that two qubits are **entangled** if and only if $ru \neq st$.

2 Qubit Tick

Assume we have two qubits given by $\vec{\mathbf{a}}$ and $\vec{\mathbf{b}}$ that are entangled. Then, by (1) we have

$$r(\hat{\mathbf{a_0}}\hat{\mathbf{b_0}}) + s(\hat{\mathbf{a_0}}\hat{\mathbf{b_1}}) + t(\hat{\mathbf{a_1}}\hat{\mathbf{b_0}}) + u(\hat{\mathbf{a_1}}\hat{\mathbf{b_1}}) \ni ru \neq st$$

Give qubit described by the state vector $\vec{\mathbf{a}}$ to observer **A** and the qubit described by state vector $\vec{\mathbf{b}}$ to observer **B**. For the purposes of brevity we will simply call these qubit **a** and **b**. Each observer, in addition to their qubit, carries their own "synchronized" clock (we pause briefly to handwave).

Every 1 second, observer **A** measures the qubit **a** according to the basis described by $\{\hat{\mathbf{a_0}}, \hat{\mathbf{a_1}}\}$. Every 1 second, with an initial offset of half a second, observer **B** will do the same according to the same basis, $\{\hat{\mathbf{a_0}}, \hat{\mathbf{a_1}}\}$ (this may not be strictly required, but simplifies construction). Note that each measurement by both parties will retrieve an identical state of the qubit every single time, and it will be equal to one of the two basis vectors.

Now we introduce a deterministic algorithm that rotates the basis by θ every tick, such that both observers will rotate their frame of reference each time a measurement is taken.

$$\theta_{n+1} = \theta_n + \pi/4$$

Using this method, we measure n states from n ticks, using eight different bases. This will result in eight state vectors, $\vec{\mathbf{s_0}}$, ..., $\vec{\mathbf{s_8}}$. Both **A** and **B** will observe these same eight values in the same order from their individual qubits.

3 Time Dilation

We need to describe precisely how this qubit tick will become useful for two objects that were once close and are now far apart (superluminal communication has no use when objects are close together). We wish to find how velocity of these observers affects the tick, so that the observers can move apart rapidly yet still keep the precise order required for **A** to transfer information to **B**.

Assume observer **B** is moving away from **A**. If the time interval $T_b = t_2' - t_1'$ is measured in the reference frame of the receiver, **B**, then we can calculate $T_a = t_2 - t_1$ measured in the reference frame of **A**.

$$
\begin{aligned}
T_a &= t_2 - t_1 \\
&= \sqrt{\frac{t_2 + \frac{vx_2}{c^2} - t_1 - \frac{vx_1}{c^2}}{\sqrt{1 - \frac{v^2}{c^2}}}} \\
&= \frac{T_b}{\sqrt{1 - \frac{v^2}{c^2}}} \\
&= T_b \gamma
\end{aligned} \tag{2}
$$

Since we can calculate this γ based on a previously agreed upon constant velocity, we can calculate how to dilate the tick and keep the ordering that **A** always measures the qubit before **B**.

4 Construction

Now we have two observers with a method of checking the value of a qubit and we can scale the ticks of the two observers to guarantee ordering, i.e. that **A** always checks the value of **a** before **B** checks the value of **b**. If observer **A** could determine which basis vector a qubit would fall to, it becomes trivial to encode data in $\mathbf{R}^2$ by using the basis vectors. A qubit with value $\hat{\mathbf{a_0}}$ can be a 0 and a qubit with value $\hat{\mathbf{a_1}}$ can be a 1. Any binary data could then be encoded, given a long enough timeline at our measly baud rate of 1 bit per second (of course, using the Lorentz Transformation as our guide, we can speed up the tick frequency as long as we ensure ordering).

Herein lies the problem: **A** cannot force a qubit to collapse to a specific basis state. Perhaps we could construct qubits with probability amplitude specifically designed such that a specific basis vector is *usually* chosen– but then that basis is useless for transferring data because it will usually collapse to a single value.

In short, we have described nothing of value but now have a deeper understanding of exactly why superluminal communication via entanglement is non-existent, or at the very least, non-productive.