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	Comments Regarding Contribution C802.16maint-06/072
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Re:	Proposed resolution in C802.16maint-06/072
Abstract	
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Comments Regarding Contribution C802.16maint-06/072

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1 Problem Statement

The problem presented in Contribution C802.16maint-06/072 is important and valid. And may be summarized as a problem of filtering a non-uniformly sampled process. To be more specific, the current standard states that the mean CINR statistics $\hat{\mu}_{CINR}[k]$ is derived from the instantaneous CINR measurements CINR$[k]$ using the first-order IIR

$$\hat{\mu}_{CINR}[k] = (1-\alpha_{avg})\hat{\mu}_{CINR}[k-1] + \alpha_{avg}\mathrm{CINR}[k], \quad \text{for } k > 0. \tag{1}$$

Obviously, (1) makes sense when the process CINR$[k]$ is uniformly sampled. In the case where CINR measurement where not made for n Frames, the authors of Contribution C802.16maint-06/072 suggest using the following equation

$$\hat{\mu}_{CINR}[k] = (1-\alpha^n)\hat{\mu}_{CINR}[k-1] + (1-(1-\alpha)^n)\,\mathrm{CINR}[k], \quad \text{for } k > 0, \tag{2}$$

where n is the number of frames in which no measurements were taken.

We note that in in the case of $n \neq 0$ Eq. (2) differs from (1) only in one instance (immediately after the non measured Frames). This behavior of the solution seems problematic since it significantly differs from standard

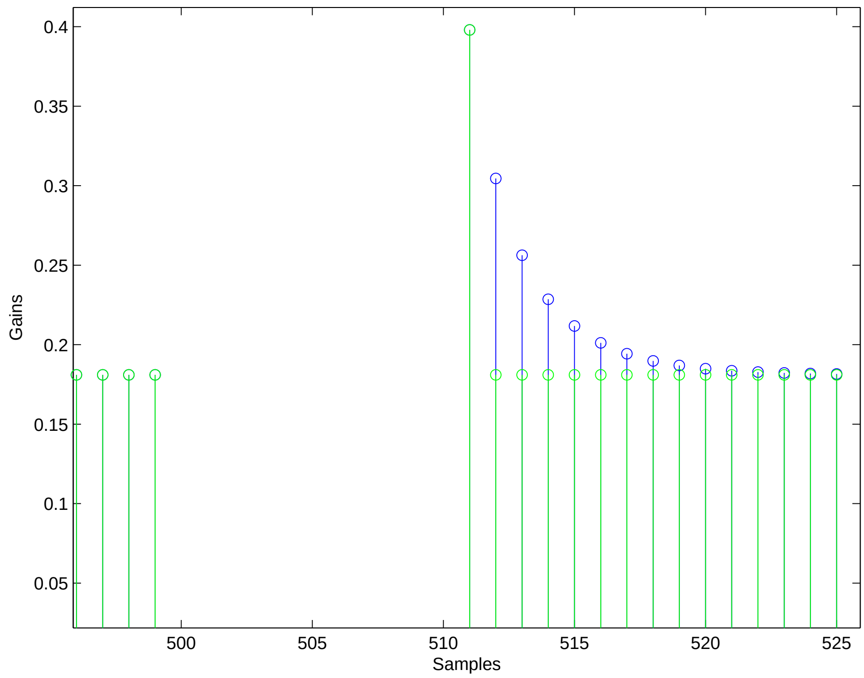

Figure 1: The proposed gain sequence (Green) Vs. the exponential Kalman gain sequence (Blue)

solutions for (mathematically) similar problems. The gain sequence of the filter (2) and that implied by standard Kalman theory is given in Fig. 1. The figure shows that the Kalman results in an exponentially decaying gain that is missing from (2). From an engineering point of view, the Kalman solution is much more intuitive because it is not reasonable that the gain differs only in the Frame after the non-measured Frames. Thus, Contribution C802.16maint-06/072 suggests replacing one (very) suboptimal solution (1) with another (2).

2 Proposed Remedy and Changes

We propose to apply a (simple) adaptive solution to the problem of non-uniform sampling at hand. The proposed solution takes the form (for $k > 0$)

$$\begin{aligned} \hat{\mu}_{CINR}[k] &= \hat{\mu}_{CINR}[k-1] + \frac{P^-[k]}{P^-[k]+1}\left(\mathrm{CINR}[k] - \hat{\mu}_{CINR}[k]\right) \\ P^-[k+1] &= \left(1 - \frac{P^-[k]}{P^-[k]+1}\right) P^-[k] + \frac{\alpha_{avg}^2}{1-\alpha_{avg}}(n[k+1]+1), \end{aligned} \tag{3}$$

with initial conditions $\hat{\mu}_{CINR}[0] = \mathrm{CINR}[0]$ and $P^-[1] = \frac{\alpha_{avg}^2}{1-\alpha_{avg}}(n[1]+1)$. Here again $n[k]$ is the number of non-measured Frames before the k-th measurement (it is important to note that $n[k]$ is a function of k). The derivation of (3) is given in the Appendix.

We propose to keep all suggested text changes in Contribution C802.16maint-06/072 accept the following.

- Replace Eq. (146a) in C802.16maint-06/072 with Eq. (3).

- Replace "... and n is number of consecutive frames in which no measurement is made" (below Eq. (146a)) with "... and n[k] is number of consecutive frames in which no measurement is made before the k-th measurement".

3 Appendix - Mathematical Derivation

The main idea behind the derivation is the application of the best linear estimator (Kalman filter) to the problem of non-uniform sampling of a random process. This procedure is done in a way that the solution coincides with the first order IIR (1) in the case of uniform sampling (n=0).

We note that the mathematical model for a process x_k (representing $\mu_{CINR}[k]$) and its measurements in white noise y_k (representing CINR$[k]$) for which a first-order IIR is optimal is

$$\begin{aligned} x_k &= x_{k-1} + \sigma_k w_k \\ y_k &= x_k + \rho_k v_k, \end{aligned} \tag{4}$$

where w_k and v_k are uncorrelated discrete white noises. The optimal estimator of x_k given $[y_0 \ldots y_k]$ is given by the following recursions (Kalman)

$$\begin{aligned} K_k &= \frac{P_k^-}{P_k^- + \rho^2} \\ \hat{x}_k &= \hat{x}_{k-1} + K_k\left(y_k - \hat{x}_{k-1}\right) \\ P_{k+1}^- &= \left(1 - K_k\right) P_k^- + \sigma_{k+1}^2. \end{aligned} \tag{5}$$

It is well known that (for the model (4)) the Kalman gain series K_k converges to a steady-state solution (our α_{avg}). Another known fact is that the filter is determined by the ratio $\frac{\sigma}{\rho}$. This implies that we may continue with $\rho = 1$ without loss of generality.

An immediate implication of the above is that α_{avg} determines the constant σ_k is the steady-state of uniform sampling by

$$\sigma_k^2 = \frac{\alpha^2}{1-\alpha}. \tag{6}$$

Thus, in the case of n_k non-measured Frames (before the k-th sample) we simply obtain

$$\sigma_k^2 = \frac{\alpha^2}{1-\alpha}(n_k + 1). \tag{7}$$

Substituting $\rho = 1$ and (7) in the Kalman filter (5) we obtain (3).