If\(\mu_1\)Southeast University,\(\Sigma\)optimization results with
problem has been addressed in some previous works, but pilot
length which maximizes the sum rate per cell is put forward.
interference users. This increases the pilot length, following for
contamination issue, which persists even with unlimited BS
estimation, which is typically performed using uplink pilot training.
sequences can be used to expand the distance between
data transmission. Here, we are interested in determining the
performance. In the asymptotic massive MIMO regime, the
improved channel estimation, however, it also reduce the time for
optimization problem

\[\tau^* = \arg\max_{\tau} \frac{\tau^2}{\tau^2 + \Sigma_i \alpha_i} \sum_i \alpha_i \]

The key proce\(\mu_1\)to find a tractable expression for the
achievable rate \(R_u\).

For MRC receivers, we present an approximation\([7]\)

\[R_u^\text{MRC} = R_u^\text{ZF} \frac{\sum_i \alpha_i}{\sum_i \alpha_i} \left(1 + \frac{\tau^2}{\tau^2 + \Sigma_i \alpha_i} \sum_i \alpha_i \right)\]

The optimal pilot length should not be dependent on a specific
user location. To remove the dependence:
Central users use power control to compensate
\(p_u \beta_i \rightleftharpoons \lambda_{i} \)
Other users use the average value to replace
Applying these assumptions into achievable rate (take MRC
receivers for example), we can get

\[R_u^\text{MRC} = \log_2 \left(1 + \frac{\tau^2}{\tau^2 + \Sigma_i \alpha_i} \sum_i \alpha_i \right)\]

The original optimization problem can be simplified as

\[\tau^* = \arg\max_{\tau} \frac{\tau^2}{\tau^2 + \Sigma_i \alpha_i} \sum_i \alpha_i \]

Due to \(\tau \geq N\nu\), curves with different \(\mu_1\)have a different starting
point. It can be found that when \(\mu_1 = 1\), as expected, the sum
rate first increases and then decreases. For larger \(\mu_1\), the sum
rate almost monotonically decreases. This can be explained
by the benefit brought by a slightly better estimation is
negligible as compared with the loss in transmission time.

Future Work
This work focuses on the case where number of users and
the pilot reuse pattern is fixed. This is a start of our research.
Next we will continue this work to more complicated cases.
Find the optimal pilot length with unknown number of users
and pilot reuse pattern.
Find the optimal pilot reuse pattern with known or unknown
pilot length.
Optimize the pilot length, number of users and pilot reuse
pattern at the same time.
These works are ongoing. Please looking forward to our
journal version paper.

References
numbers of base station antennas,” IEEE Trans. Wireless Commun., vol. 9,
and precoding in multicell TDD systems,” IEEE Trans. Wireless Commun.,
noncooperative TDD large scale antenna systems,” IEEE J. Sel. Areas
power and training duration allocation,” IEEE Wireless Commun. Lett., vol. 2,
nos. 6, pp. 605–608, Sept. 2014.
spatial efficiency: How many users and pilots should be allocated?” IEEE
uplink massive MIMO systems with arbitrary-rank channel means,” IEEE J.
Nov. 2007.

OPTIMAL OPTIMAL PILOT LENGTH FOR UPLINK MASSIVE MIMO SYSTEMS WITH PILOT REUSE
Qi Zhang‡, Shi Jin*, David Morales§, Matthew McKay§, and Hongbo Zhu‡

*National University of Posts and Telecommunications, *Southeast University, §Hong Kong University of Science and Technology