2 Quantifying Fuel-Saving Opportunities from Specific Driving Behavior Changes

2.1 Savings from Improving Individual Driving Profiles

2.1.1 Drive Profile Subsample from Real-World Travel Survey

The interim report (Gonder et al. 2010) included results from detailed analyses on five cycles selected from a large set of real-world global positioning system (GPS) travel data collected in 2006 as part of a study by the Texas Transportation Institute and the Texas Department of Transportation (Ojah and Pearson 2008). The cycles were selected to reflect a range of kinetic intensity (KI) values. (KI represents a ratio of characteristic acceleration to aerodynamic speed and has been shown to be a useful drive cycle classification parameter [O'Keefe et al. 2007].) To determine the maximum possible cycle improvement fuel savings, the real-world cycles were converted into equivalent "ideal" cycles using the following steps:

1. Calculate the trip distance of each sample trip.
2. Eliminate stop-and-go and idling within each trip.
3. Set the acceleration rate to 3 mph/s.
4. Set the cruising speed to 40 mph.
5. Continue cruising at 40 mph until the trip distance is reached.

To compare vehicle simulations over each real-world cycle and its corresponding ideal cycle, a midsize conventional vehicle model from a previous NREL study was used (Earleywine et al. 2010). The results indicated a fuel savings potential of roughly 60% for the drive profiles with either very high or very low KI and of 30%–40% for the cycles with moderate KI values.

Table 2-1 takes the analysis of these five cycles from the interim report a step further by examining the impact of the optimization steps one at a time in isolation. As indicated by other simulations from the interim report (Gonder et al. 2010), acceleration rate reductions can deliver some small fuel savings, but avoiding accelerations and decelerations (accel/decel) altogether saves larger amounts of fuel. This suggests that driving style improvements should focus on reducing the number of stops in high KI cycles, and not just the rate of accelerating out of a stop.

Table 2-1. Simulated fuel savings from isolated cycle improvements

Cycle Name	KI (1/km)	Distance (mi)	Percent Fuel Savings			
			Improved Speed	Decreased Accel	Eliminate Stops	Decreased Idle
2012_2	3.30	1.3	5.9%	9.5%	29.2%	17.4%
2145_1	0.68	11.2	2.4%	0.1%	9.5%	2.7%
4234_1	0.59	58.7	8.5%	1.3%	8.5%	3.3%
2032_2	0.17	57.8	21.7%	0.3%	2.7%	1.2%
4171_1	0.07	173.9	58.1%	1.6%	2.1%	0.5%

Figure 2-1 extends the analysis from eliminating stops for the five example cycles and examines the additional benefit from avoiding slow-and-go driving below various speed thresholds.

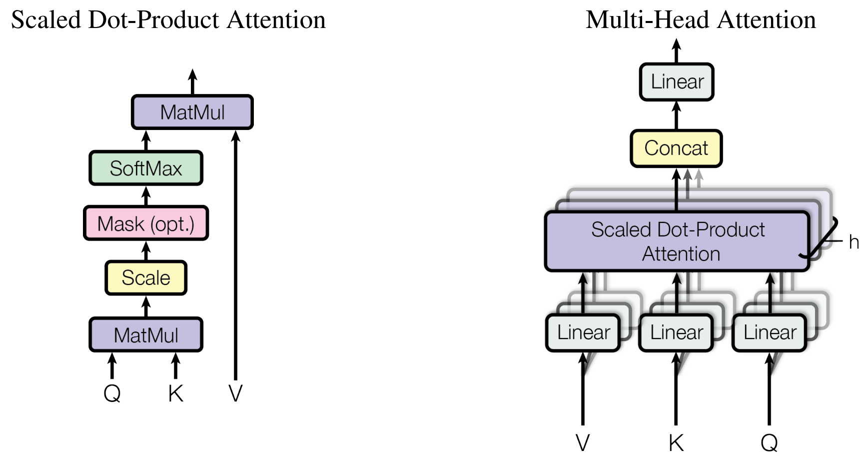

Figure 2: (left) Scaled Dot-Product Attention. (right) Multi-Head Attention consists of several attention layers running in parallel.

of the values, where the weight assigned to each value is computed by a compatibility function of the query with the corresponding key.

3.2.1 Scaled Dot-Product Attention

We call our particular attention "Scaled Dot-Product Attention" (Figure 2). The input consists of queries and keys of dimension d_k, and values of dimension d_v. We compute the dot products of the query with all keys, divide each by $\sqrt{d_k}$, and apply a softmax function to obtain the weights on the values.

In practice, we compute the attention function on a set of queries simultaneously, packed together into a matrix Q. The keys and values are also packed together into matrices K and V. We compute the matrix of outputs as:

$$\mathrm{Attention}(Q, K, V) = \mathrm{softmax}(\frac{QK^T}{\sqrt{d_k}})V \tag{1}$$

The two most commonly used attention functions are additive attention [2], and dot-product (multi-plicative) attention. Dot-product attention is identical to our algorithm, except for the scaling factor of $\frac{1}{\sqrt{d_k}}$. Additive attention computes the compatibility function using a feed-forward network with a single hidden layer. While the two are similar in theoretical complexity, dot-product attention is much faster and more space-efficient in practice, since it can be implemented using highly optimized matrix multiplication code.

While for small values of d_k the two mechanisms perform similarly, additive attention outperforms dot product attention without scaling for larger values of d_k [3]. We suspect that for large values of d_k, the dot products grow large in magnitude, pushing the softmax function into regions where it has extremely small gradients [4]. To counteract this effect, we scale the dot products by $\frac{1}{\sqrt{d_k}}$.

3.2.2 Multi-Head Attention

Instead of performing a single attention function with d_{model}-dimensional keys, values and queries, we found it beneficial to linearly project the queries, keys and values h times with different, learned linear projections to d_k, d_k and d_v dimensions, respectively. On each of these projected versions of queries, keys and values we then perform the attention function in parallel, yielding d_v-dimensional

[4] To illustrate why the dot products get large, assume that the components of q and k are independent random variables with mean 0 and variance 1. Then their dot product, $q \cdot k = \sum_{i=1}^{d_k} q_i k_i$, has mean 0 and variance d_k.

波斯的“蒲式耳”（bushel）被包括埃及在内的东地中海世界诸国家和地区沿用至今。①

货币、度量衡标准化及两者在中央与地方的双轨制，促进了帝国内部贸易及对外贸易发展。波斯人虽然居于山区，对海上贸易所知甚少，但为促进东西部地区贸易往来，利用被征服的有航海经验的“腓尼基人”② 和小亚希腊人开展海上贸易。于是，在阿契美尼德王朝时期，无论是贸易额还是范围都超过往昔，希腊、腓尼基、埃及和印度商人往返于印度、西亚和埃及之间。

阿契美尼德王朝频繁的战事不仅扩展了波斯帝国的政治版图，也扩展了其贸易版图。波斯大军所到之处，就是波斯人贸易活动展开之所，与战事相伴是阿契美尼德王朝对外贸易的一个特征。在描述冈比西斯二世征服埃及时，希罗多德直白地记载道：“与大军同行的一部分希腊人是来做生意的。”③

波斯帝国幅员辽阔，但受限于交通和人力等条件，无法对所有行省进行税收监管。为此，阿契美尼德王朝从大流士一世开始便推行包税制，即在规定了各行省的固定税额后，允许它们将其分解转包给当地包税商。包税商以波斯帝国之名征税，但征缴的钱物远大于需上缴给波斯中央政府的税额。为获得更大经济利益，他们又把多收缴的诸如粮食、布匹等实物进行贩卖。由此，包税制度演变为一种贸易形式。波斯人的包税制度后来被罗马帝国仿效，成为罗马帝国税收制度的主要形式之一。

阿契美尼德王朝在经济领域实行货币和度量衡双轨制，在确保中央政府绝对权威和利益最大化前提下，给各地以相对独立的经济自治权，助推了帝国经济繁荣。

四、邮驿系统基础上的行省制度

为将全国各地纳入统一行政管理体系，方便军队调动和经济往来，从大流士一

① J. D. Ray, “Egypt 525-404 B.C.,” p. 269.

② 腓尼基既不是地理单位，亦非政治单位，而是分布在今叙利亚、黎巴嫩、以色列、土耳其等地中海东部沿海地区的狭长地带。关于腓尼基的称谓和来源，学界仁智各见。有学者认为，希罗多德等希腊古典作家对腓尼基的称谓（罗马人称“腓尼基”为“布匿”），可能来自埃及人对迦南的称谓，参见 Ju. B. Tsirkin, “Canaan, Phoenicia, Sidon,” *AuOr*, Vol. 9, No. 2, 2001, pp. 271−280. 由于该地带居民服饰尚紫，所以希腊人称其所居之地为腓尼基，“腓尼基人”也即“来自紫色国度的人”，参见 M. C. Astour, “The Origin of the Terms‘Canaan’,‘Phonenician’, and‘Purple’,” *Journal of Near Eastern Studies,* Vol. 24, No. 4, 1965, pp. 346−350.

③ Herodotus, *Histories*, 1.188, 3.139.